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An Illustrated Weekly Journal

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THE PRINCE'S PLEASURE

"THE pleasure of a prince is unto others a law": with these words Sir Philip Morris introduced his summing-up of the Duke of Edinburgh's Study Conference on the Human Problems of Industrial Communities within the Commonwealth and Empire, to give it its full, unwieldy title. Although the Duke himself rather wryly remarked that in modern times the old Latin tag might more appropriately be reversed, there is no doubt that his acceptance of the suggestion for such a conference made by the Industrial Welfare Society gave it a prestige it would not otherwise have had and attracted a committee and contributors well above the average in status and quality.

The announcement of the conference met with a good deal of scepticism and some open hostility and its sponsorship was a courageous act on the part of the Duke, for if it had failed or led to factious controversy it would undoubtedly have exposed him to criticism and embarrassment. It can be said at once that the conference was successful, although it may never be possible to assess the exact advantage that either individuals, industry or the community will have obtained from it. Conceived four years ago, largely as a United Kingdom venture with visitors from the Commonwealth, it was the Duke himself who transformed it into a predominantly Commonwealth undertaking; and it was in the close partnership which developed in the 20 study groups that the main benefit to the individual participants will be found.

The organisation was first class and, in itself, a demonstration of our native talent for administration. Many a Commonwealth visitor was made to realise for the first time that there are plenty of brains still left in the mother country. On the other hand, if any of the organisers or the industrialists and local worthies who entertained and were interviewed by the visiting groups had any idea of patronisingly instructing their visitors, they will have received a rude shock; for the exchanges of opinion appear to have been frank in the extreme. It did not take the overseas visitors long to discover our most serious failing, our resistance to change; although on this subject it was notable that one of the groups reported on the advantages of a stable society based on traditions as being conducive to peaceful change, provided that the traditions themselves include the idea of the flexibility of institutions.

The form of the conference was highly original, combining in a few weeks the private reading and lectures of a university course with the field work and seminars of post-graduate work in the social sciences. The background papers which the participants were expected to have read before they arrived were admirable introductions to the themes the groups were to study; some of the formal lectures were stimulating to the point of provocation and most of them must have introduced their hearers to new ideas; while the elaborately drawn up programmes of the study tours ensured the maximum value out of the limited time available. The groups themselves, with chairmen and secretaries provided from U.K. industry, were each a balanced team of managers and trade unionists, drawn from all parts of the Commonwealth.

It would be unrealistic to expect such a conference to come to any original conclusions on a subject to which so much thought and study have been devoted in the last few years, especially as no attempt was made to promote any particular idea or to pronounce judgment on the problems examined. Nevertheless, there was a surprising unity in some of the conclusions reached. It was to be expected that there would be an insistance on the necessity of recognising the significance of the individual, on the importance of integrity and sincerity in management, and on the need for more and better education; but it was surprising to find suggestions that all monotonous work is not disliked; that paternalism is popular in some communities; that the fact that workers do not use the social and athletic amenities provided by their firms may be a good thing; and that social apathy in new towns may in reality be a sign of self-reliance. The members of one group were emphatic that the best spirit that they had found was among the people of Poplar.

The science of society, including industrial institutions, is still at an elementary level, and the main conclusion that might be drawn from what is so far known to the social scientists was confirmed by the reports made to this Conference: that the infinite variety of human personality leads to an equally infinite variety of human institutions. There are not many laws which are true for all large firms or all small firms; for all public companies, all family businesses or all nationalised undertakings. There are lessons to be learnt from the history of the industrialisation of one country, but they must be applied with care in another.

If one asks what are the chief returns of this very extensive enterprise, no doubt in the short term it will be the knowledge gained by those who will be responsible for the introduction of industry into what at present are simple rural communities. In the long run, however, it must be to the

advantage of the whole Commonwealth that close contacts of this kind should have been made on a completely new level. Most of those who participated in this Conference are destined to play some leading part in the industrial future of their countries. They are unlikely to forget either their experiences or their colleagues of these three weeks.

* * *

Plain Words

Every year a great deal of time is spent in litigation over engineering contracts. These disputes involve considerable expense whether they are conducted in the courts or before arbitrators; they often involve the preparation of elaborate schedules and other documents to illustrate what has actually occurred. The whole process causes unnecessary disruption and friction. It can cost a lot of money. While a dispute lasts there is often delay in settling accounts and much damage can be done to confidence and good-will. All these difficulties are heightened when the contract in question is international in character.

It is commonly supposed that the delay and expense involved in a court case can be avoided by providing in the contract that any dispute shall go to arbitration. Such a belief is largely mistaken since arbitration is neither cheap nor quick and the matter often ends up in the courts after all. The only real cure is to see that contracts are so drafted that they obviate as many causes of dispute as possible. This cure is, of course, partly a matter for legal advice; but only partly. Legal advisers, when they are drafting a contract or vetting a prepared draft, are acting mainly as translators. Their job in this instance is to translate into legal phraseology the desires and intentions of the contracting parties. They can only do their job properly, however, if the parties to the contract know clearly what are their intentions.

If a contract is to be effective, the parties to it must have thought out clearly and thoroughly their aims and objects. They must, among many other things, have decided what they wish to occur if arrangements do not go according to plan. This is where the engineer has a most important part to play. The contract provisions will be good or bad depending upon how well the engineer has foreseen eventualities and provided for them.

Clearly the engineer cannot tell the draftsman of the contract everything that he has decided. What then should the engineer tell him? In an attempt to assist engineers to find the answer to this question we are publishing a series of about ten articles at approximately fortnightly intervals. The first appears in this issue. These articles will indicate the most frequent points of difficulty which arise in contract disputes and which, we believe, can be largely eradicated by clear instructions from the engineer. The articles will have special reference to the many standard forms of contract now widely used. We hope that the suggestions these articles contain may help in reducing the number of legal disputes in engineering contracts.

HIGH SPEED PHOTOGRAPHY

APPLICATIONS IN ELECTRICAL RESEARCH

By H. H. W. Losty, B.SC.*

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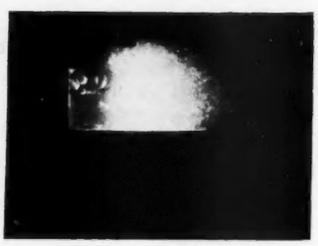

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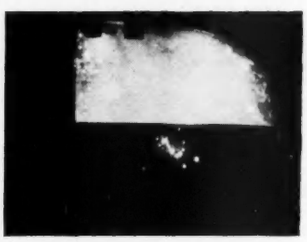

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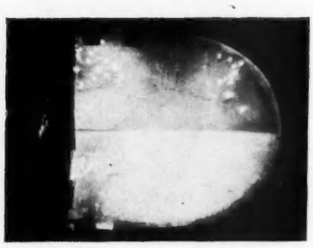

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Fig. 1 Studies of the successive stages of ignition of a multiple-charge photoflash lamp. Stage (d) shows how a small hot particle (lower centre) from the first charge has travelled across the dividing wall causing undesired ignition of the second charge.

The development in the last 20 years of simple and robust apparatus capable of taking photographs at the rate of several thousand pictures per second has led to a great increase in the use of photographic techniques in research and engineering. Motion picture photography has, of course, been successfully applied to the recording of events for a great many years; consideration of how these records are obtained will help in understanding the need for high speed photography.

In the conventional motion-picture camera, a series of single pictures is taken on a roll of film at the rate of 16 or 24 pictures per second. To achieve this the film is moved intermittently through the image plane of a camera lens by means of a claw or intermittent sprocket mechanism engaging in perforations in the edge of the film. A rotating shutter connected to the film drive cuts off the light from the film when it is moving, and allows exposure to be made only when the film is stationary. The event is thus recorded as a series of single pictures, and it is possible to examine the motion of any particular object by studying the film picture by picture. When this film is projected at the same speed by a mechanism similar to that in the camera, the illusion of continuous motion is created.

This system is obviously flexible and, if the rate at which the picture is taken is faster than that at which it is projected, the motion will appear to have been slowed down. Since, for the motion to appear continuous, the film cannot be projected at less than about eight to twelve pictures per second, it is necessary to increase the rate at which the pictures are taken. The conventional motion picture camera is limited to about 250 pictures per second by the mechanical strength of the film, which has to be able to withstand the high forces necessary to pull it through the camera. Time magnifications of about 20 can therefore be obtained in this way. This is adequate for the slow-motion effects used by the film industry for horse races and similar events, but not for the detailed analysis of the rapid motions encountered in modern machines. In addition, it is necessary that the image of the component should not move a greater distance on the film than the film can resolve; this would result in blurring and would reduce the accuracy with which its position could be determined, or even make the pictures unreadable.

ROTATING PRISM

To overcome these difficulties, cameras have been developed which are capable of taking pictures at the rate of several thousand per second. The mechanical strength limitation of the film is overcome by running it continuously through the camera. To allow single pictures to be taken, a solid glass prism is placed between the lens and film and is rotated at such a speed that the image moves downwards at the same speed as the film. The prism is housed in a cylindrical shutter which cuts off the light from the film for about four-fifths of each cycle, thus permitting a sequence of separate single pictures to be taken. This film can then be projected on the conventional intermittent projector to create the illusion of continuous motion. The upper limit of speed for this type of camera is again determined by the mechanical properties of the film, in this case its ability to withstand the acceleration necessary to raise the film speed from zero to the required velocity in a reasonable fraction of the normal 50 or 100 ft. of the reel of film. The limiting speed is between 75 and 100 ft. per second, which allows pictures to be taken at the rate of about 1,000 frames per second for 35 mm., 4,000 for 16 mm., and 8,000 for 8 mm. film.

One of the most frequently-used cameras of this

* Research Laboratories of the General Electric Company, Limited, Wembley.

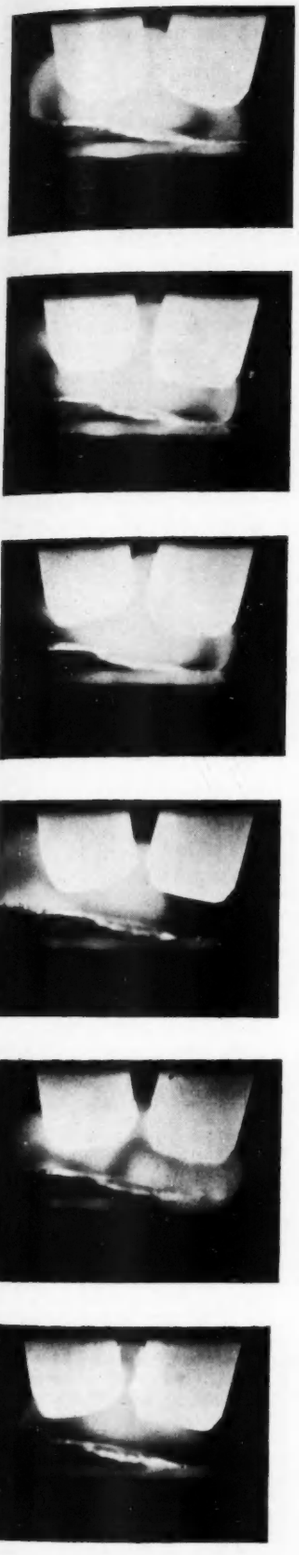


Fig. 2 Appearance of argon welding arc at various stages during a 1/50 second cycle. In particular, Fig. 2 (e) shows the arc when the work is negative with respect to the tungsten rods. The bright spots indicate electrons emitted from pieces of oxide floating in the molten pool, demonstrating that the negative cycle assists in removing oxide from the weld area.

type, the Eastman Kodak high-speed camera which can take 3,000 pictures per second on 16 mm. film, has now been in use for the past eight years at the Research Laboratories of the General Electric Company, Limited, Wembley, and has been applied to the investigation of many problems encountered there.

At a picture speed of 3,000 frames per second, the effective exposure of each frame is 1/15,000 second. To apply this camera to the study of non-luminous objects, such as high-speed mechanical devices, it is therefore necessary to provide high levels of continuous illumination. With a lens aperture of f 2·7 at the maximum speed of operation, 15,000 ft. lumens are required to obtain full exposure of the film. This is greater than the brightness of a light object in the brightest noon sunlight. To achieve adequate depth of focus, over 10 times this brightness may be required. Most applications require an area up to 1 ft. square to be viewed. This can readily be achieved by using four 115 volt 250 watt sealed-beam infra-red heating lamps, run up by means of a Variac to about 240 volts. These sealed-beam lamps are small in size, and it is a simple matter to place them between 6 and 18 in. away from the subject. If larger areas are to be viewed, it is necessary to use either tungsten or arc studio spotlights.

The following examples have been selected from the many problems studied, in order to demonstrate the uses of this high-speed photographic technique.

PHOTOFLASH AND ARGON ARC STUDIES

The photoflash lamp is now a familiar aid to the photographer. It consists of a glass envelope containing shredded foil or wire of aluminium or one of its alloys in an atmosphere of oxygen. The charge is ignited by means of a combustible paste set off by an electrically fused wire. In most types of lamp, the whole flash lasts only about 1/40 second and cannot be resolved visually. If, however, a high-speed film is taken at 3,000 frames per second, the flash is apparently extended to approximately 5 seconds. The whole cycle can then be broken down into 75 separate pictures and studied frame by frame.

One particular problem examined was the behaviour of an experimental lamp in which several charges were sealed into a single chamber, to be ignited one at a time. In the early experiments the charges were separated by metal or mica shields which were made as tight a fit in the container as manufacturing tolerances allowed. It was found that when one compartment was fired the remainder also ignited, and a high-speed film was taken to discover the cause. The results are shown in Fig. 1, where some single frames from the film are reproduced. Photographs (*a*) ,(*b*) and (*c*) show successive stages in the ignition of the first compartment. In the central lower part of (*d*), a small hot particle has travelled across the dividing wall, igniting first the foil and then the primer. This film clearly indicated the method of ignition, and eliminated either hot gases or radiation transfer as possible causes. The solution adopted was to place the charges in loose-fitting glass tubes the ends of which were stopped with glass wool, and this proved completely successful.

Another example of a self-luminous object studied was the twin-phase argon welding arc used in the manufacture of aluminium-sheathed cable. Fig. 2 shows a sequence of photographs demonstrating the arc appearance at various stages in one cycle of 1/50 second. The two tungsten rods are connected to each of the phases of a twin-phase transformer and the cable to the neutral. In particular, Fig. 2 (*e*) shows the arc when the work is negative with respect to the rods. Bright spots can be seen as electrons are emitted from pieces of oxide floating in the molten pool. This demonstrates that the negative cycle materially assists in the removal of oxide from the weld area.

CHECKING ELECTRO-MECHANICAL COUNTER

An interesting example of a non-luminous subject was the two-way mechanical counter developed for automatic control of the new high-speed wind tunnel at the Royal Aircraft Establishment at Bedford. In this system, electrical impulses are fed into an electro-mechanical device which automatically counts them, adding or subtracting according to their sign. The essential mechanical clutch and detent device are shown in Fig. 3. The switches are required to make 30 million counts without error during their life and are tested for 250 thousand counts before leaving the factory. The toothed dog clutch is indicated by the arrows in Fig. 3, and the detent, comprising a spring-loaded roller engaging with a cog wheel, is seen on the left. So long as the clutch is disengaged, the roller prevents the cog wheel from turning. When the dog clutch engages, the roller springs downwards and allows the cog to advance one tooth space. Several high-speed films were taken, which extended the time of each counting operation from 1/20 second to 10 seconds. It will be seen from the selection of frames in Fig. 3 that this was adequate to obtain complete resolution In particular the behaviour of the dog clutch and detent device was systematically studied as the initial settings of spring pressure and shaft friction were varied.

From studies such as this, it is possible to determine any unwanted bounce in the detent roller or incorrect engagement of the teeth of the driving dogs which would be likely to cause early failure of the device. Such faults can be quickly detected without having to resort to the time-consuming procedure of life test to failure when each minor modification is made. It is also possible to follow the behaviour of a unit through its initial tests to determine how these faults change with time, which again can lead to an accurate assessment of potential causes of failure.

Techniques similar to those described in the foregoing examples have also been successfully employed in a number of other fields. These range from studies of telephone selector switches and kindred electromechanical devices to an examination of the trajectories of small charged particles in electrostatic fields in a study of the electrostatic separation of minerals.

STREAK CAMERA

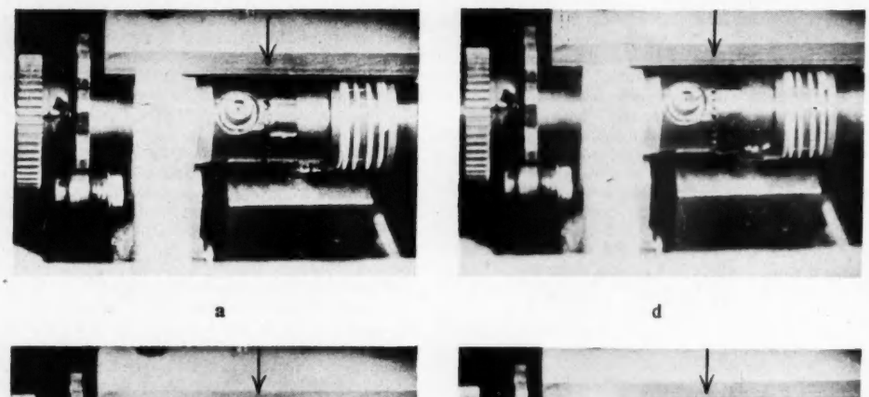
Although the maximum speed of the camera is adequate for nearly all the problems encountered, still greater speeds are occasionally required to resolve specific motions. While cameras have been designed to take motion pictures at very much greater speeds than those described above, these are usually " tailor-made " instruments for particular problems and are not yet in more general use. Greater speeds can, however, be achieved with the given camera by using it as a streak camera and thus increasing its range considerably. In this method the prism is removed and the gate exchanged for a narrow slit. An image of the salient point together with a reference mark is formed on the slit and the film is run past continuously. Although no separate images are formed as the object moves across the slit, the position of the image moves and, if the film speed is known, the time-position relationship can be determined.

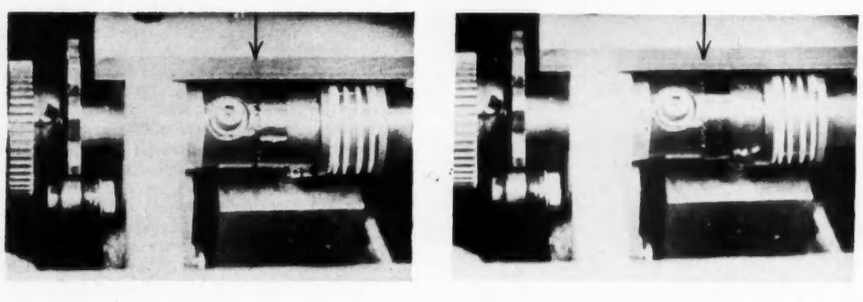
An example of this technique is shown in Fig. 4. The subject was the whisker in one type of silicon diode and the film shows its behaviour when a mechanical impulse is applied. The whisker was 0·2 mm. in diameter and the record which included a reference mark, shows that the amplitude of vibration was 0·03 mm. and the frequency 4,000 cycles per second. The advantages of this technique are that higher time resolutions can be obtained and that the resultant records are much simpler to interpret quantitatively. It is, however, limited to cases where it is required to study the behaviour of only one or two components.

High-speed photographic techniques such as those described have provided solutions to many problems which would otherwise have required expensive and time-consuming trial-and-error methods. In addition they have led to a more active consideration of photographic techniques generally for solving visual problems.

LAPSE-TIME PHOTOGRAPHY

The reverse process of lapse-time, in which events occuring over long periods of time are condensed into a few minutes, has also been used. A sequence of separate pictures is again obtained, each picture being an instantaneous photograph while the interval between photographs is adjustable from a fraction of a second to as





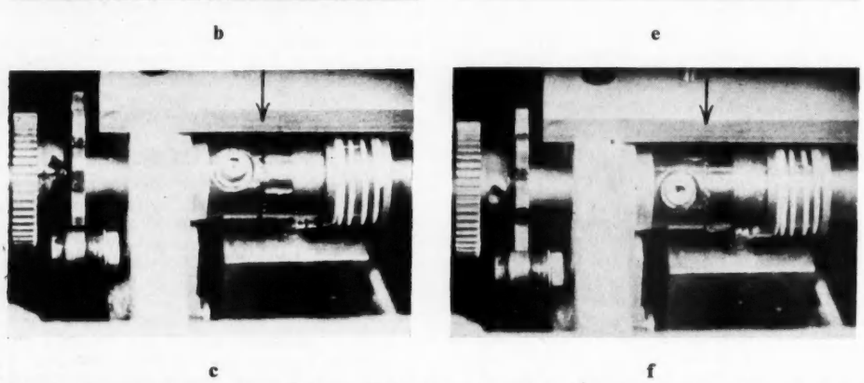


Fig. 3 Sequence of operations of the mechanical clutch, indicated by the arrow, and detent of an electro-mechanical counter developed for the automatic control of a high-speed wind tunnel at R.A.E., Bedford. Such studies can reveal faulty engagement, detent roller "bounce," etc., and the way in which such defects develop with time.

long as may be required. The interval is selected to record the event on a single roll of film, for example to give 4,000 pictures for a 100 ft. roll of 16 mm. film. The film may be projected by a conventional projector to create continuous motion or be examined frame by frame to obtain quantitative measurements. This technique has been successfully employed, for example, in a study of the creep properties of graphite. The deformation of the specimen under load was measured in terms of the relative displacement of two reference pointers attached to the specimen. The separation was recorded at 1 minute intervals by single frame photographs taken with a 16 mm. lapse-time camera. These photographs were then converted into a graph of displacement against time by projecting each frame directly on to graph paper and marking the appropriate separation. It was shown by statistical analysis of the resulting creep function that the deflection of 3 mm. was measured to an accuracy of $\pm$ 0·014 mm.

It is hoped that the examples quoted have clearly demonstrated the use of photography as an experimental technique and emphasised its important place among the tools of scientific measurement. Its application depends, not only on the ability to obtain successful photographic records, but also on the understanding by design and development engineers of how it can best be employed to assist them in finding a solution to their particular problems.

Editor's Note.—The third International Congress on High Speed Photography opens in London at the Government Offices, Horseguards-avenue, on September 10, and will continue until September 15. Concurrently an exhibition of the latest equipment will be held. Particulars may be obtained from the Congress Secretariat, D.S.I.R., Charles House, 5-11 Regent-street, London S.W.1.

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Letters to the Editor

BOUNDARY LUBRICATION

SIR, I am obliged to Mr. F. Porges, whose letter you published on page 100 last week, and to the many other correspondents who have commented on my letter in your issue of July 13.

I had two objects in mind in sending you my letter. First, its subject matter has formed the basis of a question in the final degree examination in "Mechanics of Fluids" for external students of London University for several consecutive years. I concluded, perhaps wrongly, that either this particular question was done badly or, perhaps, not at all by the majority of candidates. In order to make the theory more generally available to external students I sent you my letter.

In the second place, I had been interested to find that Professor Schlichting had given his parabolic approximation for mean pressure both in the German edition (1951) and in Dr. Kestin's English translation (1955) of his treatise. In consequence, the idea emerged that possibly no exact evaluation of mean pressure had been done previously. We now know that this is not so.

Thus I submit that, through the medium of ENGINEERING, both my objects have been achieved.

Yours faithfully,

L. E. ADAMS.

11 Milner-road,
Kingston-upon-Thames,
Surrey.
July 19, 1956.

(*Editor's Note*:—Correspondents have pointed out that Mr. Adams' analysis, which follows Schlichting as far as equation (4a) and then uses an exact integration instead of Schlichting's parabolic approximation, virtually duplicates existing hydrodynamic lubrication theory for infinitely wide slider bearings. The analysis of the slider bearing was developed by A. G. M. Michell (*Zeit. f. Math. u. Phys.*, vol. 52, pages 123-137, 1905) and is given in a number of standard textbooks, including Lamb's *Hydrodynamics*. Equation (6) is not new and will be found in different notation as equation (5.52) in M. C. Shaw and E. F. Macks' *Analysis and Lubrication of Bearings*, McGraw Hill (1949) page 167; and as equations (42) and (43) in A. E. Norton's *Lubrication*, McGraw Hill (1942) page 77.)

★ ★ ★

Metropolitan-Vickers Electrical Company, Limited, is revising its "Register of Ex-Apprentices and Ex-Trainees." The last edition, containing 10,000 short biographies, was published in 1950, and forms asking for present particulars have been sent to all those whose addresses are known to the Company. Any ex-apprentice or ex-trainee who has not received a form (or has not yet replied to one) is invited to write to Mr. R. F. Marshall, Manager, Education Department, at Trafford Park, Manchester, 17.

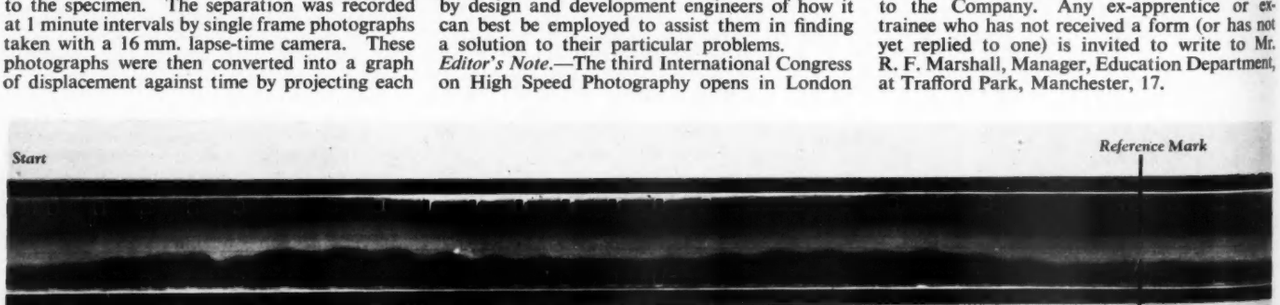

Fig. 4 A "streak" camera record of the vibration of a whisker in a silicon diode under the action of a mechanical impulse, from which the amplitude and frequency can be deduced.

Weekly Survey

Cover Picture: *More and more the process industries are using instruments which combine indication and control. The illustration shows such instruments designed for process control being adjusted for both correct indication and control operation. Above and below the selected value an impulse is relayed to the plant and causes correcting adjustments to be made.*

* * *

Credit Where it's Due

Deceived by their own speculations of a year ago when the Geneva atomic energy conference raised everybody's hopes, many observers are now expressing dissatisfaction with the progress made by the United Kingdom Atomic Energy Authority during the past year. Some newspapers bemoan the fact that we cannot yet export atomic power stations, and compare us unfavourably with the United States in this respect. Many such comments were called forth by the publication of the Authority's second annual report (summarised on page 156).

The truth, surely, is that no-one can at present export economic nuclear power stations—not even the Americans. Stations of this kind should of course be distinguished from research reactors and trial-size and package stations, which as yet are technically inefficient. Given the present fuel situation and state of reactor technology, the only atomic power stations that can hope to compete with orthodox installations are large base-load plants which can be fitted into an existing electrical system, and these would serve a useful purpose only in those extremely limited areas where, as in Britain, an acute shortage of other fuels makes the cost of power high. In any case, the Americans have even less experience of such large stations than we have. The United States atomic power programme, in both public and private sectors, has been subjected in recent weeks to numerous attacks in the Senate and elsewhere for the smallness of its scale. In Britain, four groups of private firms are already tackling the engineering problems of building full-scale stations of the Calder Hall type. (Tentative demand seems to be turning towards installations of this kind, as may be gathered from the recent interest shown by Japan.)

But complacency is a poor mentor. Britain needs a still larger programme—if her resources can be stretched to cope with it. United Kingdom dependence on Middle East oil is very precarious, especially with Colonel Nasser at large. Nuclear fuel is, of course, a major consideration in any atomic programme and here the Americans certainly have an advantage. But the uranium supply situation may not be so bad as it seems. Sir Edwin Plowden has said that as soon as any company is ready to export an atomic station, sufficient enriched uranium will be available. The Authority have recently been making considerable efforts to acquire rights to uranium deposits in Canada, Australia and Africa and seem to have been largely successful. Perhaps this is indicative of an intention to expand the British programme; in that case the Authority have been justified in concealing their intentions, so as to avoid a rise in raw-material costs. It is also significant that the question of an expanded programme has this week been raised in Parliament.

Secrecy in the field of thermonuclear fusion seems to have less justification. Although Sir John Cockcroft has assured us that it is unlikely to become a practical reality before the end of the century, by which time all capital costs for fission plants will have been recovered, no company can plan its atomic future with confidence without inside knowledge. In any case, though investment in the early stations may by then be written off, what about the later ones? But here, too, the American authorities seem as reticent as ours. Having, it appears, invited some 35 companies to participate in fusion studies, the United States Atomic Energy Commission then withdrew its invitation.

Secrecy can breed frustration and discontent, but in many sectors the Authority are declassifying information as rapidly as they can; a senior official, Mr. Benson Gyles, has recently been appointed to administer the dissemination of data to industry. It is a mistake therefore to assume that a shroud of secrecy always conceals a Civil Service cup of tea. The Americans are not always one step ahead.

* * *

Thirty Years of Automation

The Metal Box Company, Limited, have used automation for over 30 years. Most of their cans are made at speeds up to 400 a minute and much higher speeds are likely to be introduced before long. So said Sir Robert Barlow at his company's annual meeting recently. This continuous policy of making as full use as possible of electronic controls without manual intervention has brought prosperity to all concerned. Taking the last ten years alone: in March, 1947, the company employed 16,753 workers; by March, 1956, the figure had reached 24,818. This 50 per cent. increase was accompanied by an earnings increase of 200 per cent. Over the same years, turnover went up from £16 million to £61 million and the total capital employed in the business increased by 500 per cent.

Despite this large expansion in capital investment there are many processes which still need much manual work and are likely to continue to do so. Indeed, said Sir Robert, there is a serious shortage of skilled workers. Training skilled workers is one of the company's main preoccupations. There are at present over 400 apprentices under instruction as well as men training for professional and managerial posts.

The Metal Box Company's unique position in packaging (its interests range from the traditional tin can to polythene bags) has been built up by a combination of technical and managerial knowledge and organisation. The machinery building group produced nearly £2 million of equipment in 1955 and sold 25 per cent. of it abroad. To have built up this accumulation of commercial power is an outstanding combination of engineering enterprise and successful market survey work. It is true that packaging in all its forms has been expanding since the war, but it would have been easy to have gone wrong. Accurate forecasting as well as a high rate of investment per operative has been necessary to achieve success and hold it. The percentage of profit on the company's turnover in the last financial year was only 4·9 (after depreciation and taxation). The margin for bad estimating either on sales or capacity is therefore small. The recent experience of the company is a salutary corrective to those who think that automation is a crude means of creating unemployment or an easy way out for management. As capital investment per worker has increased, more men have been taken on and management and engineering techniques have become increasingly complex and interdependent.

* * *

Launch of S.T. "Evgenia Niarchos"

On Wednesday next, August 8, the S.T. Evgenia Niarchos is to be launched at Vickers-Armstrongs' Naval Construction Works, Barrow-in-Furness, for the Niarchos group. She is a tanker of 47,750 tons deadweight, a sister ship of the S.T. Spiros Niarchos which was launched in December, 1955, and is the last of an order for 10 tankers built by Vickers for this group.

Recent orders from the group have, however, all been placed outside the United Kingdom and comprise a total of 27 ships, including two large tankers of 65,000 tons deadweight to be built in Germany. Eleven of these ships—8 tankers and 3 dry cargo ships—have been ordered from Japan, and when placing these orders the group stated that Japanese shipbuilders had offered competitive and fixed prices coupled with quick delivery; 6 out of the 8 tankers will be in service by the early summer of 1957 and the other 2 by the end of that year. At the time it was placed, the order constituted the largest placed with Japanese shipbuilders since the war. More recently the Niarchos group has placed orders in both the U.S.A. and Germany and it is reported that when the current building programme is complete the Niarchos fleet will exceed 2 million tons deadweight.

The latest returns published by Lloyds Register show that for the first two quarters of 1956, U.K. shipyards were surpassed by Japanese shipbuilders in both the amount of tonnage launched and tonnage commenced, although Japanese tonnage building at the end of June, 1956, at 1,116,490 gross tons, is still very much lower than the 2,028,132 gross tons under construction in British yards. But Japan is now the largest builder of ships for export.

With four years' work in hand the immediate outlook for the British shipbuilding industry must be regarded as very satisfactory. Moreover, there appears to be little difference in shipbuilding costs as between this country and her principal competitors abroad. The main disadvantage under which the British industry is working is the long delivery which it is forced to quote, and the inability to quote fixed prices. The principal obstacles preventing an increase in output are continued shortages of steel and of labour, though it is possible that still more could be done by way of improvement in organisation designed to reduce the actual time taken to complete a ship.

* * *

Common Market in Europe

Support is steadily building up among industrialists as well as politicians for an early entry of Britain into the proposed common market in western Europe. At the recent Ministers' conference in Paris both Mr. Macmillan, Chancellor of the Exchequer, and Mr. Thorneycroft, President of the Board of Trade, gave qualified support to the idea of the common market, which was earlier described by the Economic Secretary to the Treasury as an area where "there should be a single external tariff, with no internal tariff . . . with freedom of movement of labour and capital." Sir Edward Boyle went on to say that the Government "realises completely" the "advantages which the countries inside the area should gain—that is to say a great single market within which industry could be developed to its best economic use, possessed of great bargaining power in its negotiations against outside competition."

From the point of view of British industry the idea is not without its attractions and, of course, not without its dangers. The Government have pointed out that it would not be easy to reconcile participation in a common market—which would create an industrial United States of Europe—with "our existing policies and our obligations to the Commonwealth." On the other hand if Britain does not participate and Germany does, then the results could be disastrous for British trade. But the danger does not end there: Soviet Russia and the Communist countries in eastern Europe are making a very determined effort to prise open the trade doors with the West. Should they succeed, and they are already some way there, Britain could find herself isolated from a major part of the industrialised world. The United States is likely to go on dominating trade in North America, and elsewhere there is a definite movement, which has become very marked since the war, towards local production of many of the goods—particularly metal goods—which are traditional British exports.

Last month Mr. John Hynd and 45 other Labour M.P.'s tabled a motion in the House urging the Government to take part in negotiations for a European common market. Mr. G. Rippon and other Conservatives had previously tabled a similar motion which is said to have attracted the support of more than 60 Conservatives. In a letter to *The Times*, Mr. Robert Mathew wrote "in my view it is imperative that

we should not find ourselves faced with the position that the other western European nations sign a draft treaty and leave us no alternative but to stand aside altogether or to participate on terms that we have had no part in settling." Mr. E. Beddington-Behrens, chairman of the British section, European League for Economic Co-operation, wrote last week: "After talks with some of the leading continental political personalities concerned I am convinced, so great is the desire for Britain's participation, that we can almost 'write our own ticket' as regards reasonable conditions, if we are prepared to come into a common market now. If we did it would have far-reaching political importance, apart from its economic benefits. It would restore much needed British political leadership in European affairs."

The opportunity and the challenge of the common market is now with us; to quote Sir Edward Boyle again—"I am absolutely safe in saying that there is no subject which will more attract the attention of the Government in the months ahead than this."

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Better Car Exports

In June, just over 83,000 cars were produced compared with almost 86,000 in June, 1955. Since it was a five-week month, comparison of the absolute figures with May is misleading. However, adjusting on to a four-week basis, June production was about 66,400 compared with some 55,600 in the month before. There was thus a significant jump in output, larger in fact than over May and June, 1955. There is therefore some indication that seasonal factors were pulling particularly favourably over this period. It is to be hoped that this first swallow means a real summer for the industry despite the strike.

Export figures are encouraging, though they might be misleading. In June, 30,400 cars were sent abroad compared with 29,700 in May. It was, in fact, the largest figure since September, 1955. Compared with the trend a year ago, the performance is quite striking, sufficiently so to make one wonder if June may not yet prove to have gained at the expense of July. In June, 1955, exports fell severely from 33,600 to 22,900 compared with May.

A good deal of the success, however, appears to be not in beating the Australian import restrictions but in large exports to the United States, which took 4,200 cars in June—a record performance. Some of the success behind these figures is put down to better servicing facilities in the United States. There were useful improvements elsewhere, however. Export of cars to Sweden more than doubled on the month and those to Australia also advanced. The only major market not to record an improvement compared with May was South Africa. The largest increases were in shipments of assembled cars between 1,000 and 1,600 c.c., and unassembled cars between 1,600 and 2,200 c.c. Exports of assembled cars between 2,200 and 2,800 c.c. (which brings in part of the specialist range) were, however, also encouraging. There was in fact a general recovery in exports by markets and by types. More swallows will be awaited with the July figures.

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Record Aircraft Exports

Encouraging news has come during the past week from the British aircraft industry. According to the Society of British Aircraft Constructors total exports by the industry in the first six months of the year amounted to the record figure of £55·9 million, which is 82 per cent. higher than in the same period of 1955. The total is in fact within £10½ million of the record annual figure for the whole of 1955.

During the week the de Havilland Aircraft Company confirmed that the United States Capital Airlines had ordered 14 Comet jet airliners worth about £19 million. Ten of these aircraft will be a new version, the Comet IVa, with a longer fuselage and shorter wing span, designed for short and medium hauls at a higher cruising speed and at a lower altitude than the long-range Comet IV. Each of the 14 aircraft will be powered by four Rolls-Royce Avon R.A.-29 jet engines. The value of the contract to Rolls-Royce, including the necessary spares, over a ten-year period of operation is estimated to be about £9 million. Although Capital Airlines have not expressly taken options for any further aircraft it will be remembered that their orders for the Viscount were built up progressively until they reached a total of 75.

In announcing the order, the de Havilland Company said that they would need to sell about 50 aircraft before starting to earn a profit on the Comet. They were, however, already negotiating with a number of other airlines and were confident that total orders would exceed this figure. As pointed out in the "Outlook Series" earlier this year, there is a very large potential market for medium-range aircraft and it is very probable that the decision of Capital Airlines will influence a number of other operators in favour of the Comet. With the Vickers Vanguard and Bristol Britannia there appear to be good prospects for further expansion in British aircraft exports, though there are, of course, a number of competitive United States aircraft available in both the turbo-prop and turbo-jet fields. Capital Airlines, however, decided in favour of the Comet after "the most comprehensive and detailed flight study of all flight equipment either in production or projected both in the United States and England" and this should augur well for the future of the Comet in meeting the requirements of medium-range airline operation.

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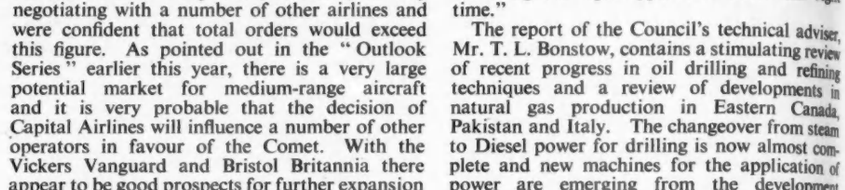
Bright Future for Petroleum Equipment

Orders booked by British manufacturers of petroleum equipment and materials in the first quarter of this year amounted to £38·5 million, over 25 per cent. more than in the last quarter of 1955. In that year orders totalled £123½ million, half as much again as the previous year. The boom is world-wide. These figures are given in the annual report of the Council of British Manufacturers of Petroleum Equipment, which contains a wealth of information on the industry's progress. The report quotes estimates of capital expenditure in the industry in the decade 1950-60 and in the five years that follow: some 50,000 million dollars and 65,000 million dollars respectively. The increase envisaged is immense —between 15,000 million dollars a year and 13,000 million. In the 10 years to 1960 only one third will have been spent outside the U.S.; in the five years 1961-65 this proportion will have risen to 38 per cent. There could be no clearer indication of the spread of the oil industry, both production and refining, to the "growth" areas of the Middle East and Europe.

The one cloud on this bright horizon is provided by the steel industry, of which many companies are members of the Council. Politely but firmly the chairman, Mr. G. V. Sims, of Le Grand, Sutcliff and Gell Limited, points out that British petroleum plant manufacturers are losing orders "owing to long deliveries making quotations uncompetitive" and lays the blame at the steelmakers' door, saying that the ratio of the increase in orders booked "is likely to be affected by this constant problem of the difficulty of obtaining the right types of steel at the right time."

The report of the Council's technical adviser, Mr. T. L. Bonstow, contains a stimulating review of recent progress in oil drilling and refining techniques and a review of developments in natural gas production in Eastern Canada, Pakistan and Italy. The changeover from steam to Diesel power for drilling is now almost complete and new machines for the application of power are emerging from the development stage. Among these are the multi-stage turbine operated by the slush-stream for driving rock, the free-piston engine for compressing air and gas, and the magnetic pump for liquid metals. Greater use is being made of fluid drives, torque converters, hydromatic brakes and of control instrumentation. Perhaps the most interesting of all new developments is described as "the invasion of the conventional rotary method of drilling oil-wells by the turbo-drill of Russian origin, developed also in Rumania and France and now to be taken in hand and improved upon in the U.S.A."



An artist's impression of the Volta River dam and power house. The dam will create a lake nearly 3,500 square miles in area. (See "Volta River Project.")

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Volta River Project

The commission that has been investigating the possibilities of large-scale aluminium production in the Gold Coast, based on harnessing the Volta river for hydro-electric power, has reported that the project is fundamentally sound technically, economically, and socially. Large reserves of bauxite, the Volta river as a source of power, suitable sites for the aluminium smelter and for a new port have combined with the urgent need for a sterling-area smelter to make an attractive proposition. To the Gold Coast, whose economy is at present dependent upon the fluctuating cacao crop, the project offers a source of income which world demand for aluminium can assure for many years.

The primary objective will be to produce 210,000 tons of aluminium per annum. This will require the development of the bauxite mines and the construction of a major dam and power installation at Ajena; there will have to be a new smelter and township near Kpong, with railway connections between the mines, the smelter and the new port of Tema, which is already under construction. An artist's impression of the dam and power station—which will generate 600 MW—is reproduced herewith. The venture, which would be controlled by the Volta River Authority with an African majority on the board, has been sponsored jointly by the Governments of the United Kingdom and the Gold Coast and two private companies, Aluminium Limited of Canada, and the British Aluminium Company. It is probable that this project has been more thoroughly investigated than any other of similar magnitude in the world. The work of the commission is contained in a report, separate appendices and an engineering report, all published by H.M. Stationery Office; the engineering report is the work of Sir William Halcrow and Partners.

Seven years are considered necessary to bring the project to initial fulfilment and the cost, at to-day's prices, is put at £230 million. Apart from the sponsors it is hoped that the World Bank might be willing to provide some assistance. Withdrawal of western help for the Aswan dam will have two effects on the Bank: the assets provisionally available for Aswan will be freed for use elsewhere, but Colonel Nasser's use of nationalisation of the Suez Canal to satiate nationalist feelings may well cause the Bank —with its strong United States background—to ignore a request from a country bent on self-determination as is the Gold Coast. For more than four years the Government of the Gold Coast have been considering the possible dangers of introducing heavy industry into a predominantly agricultural country. Now that they have concluded that their country can benefit from the project, their nationalist aspirations will best be served by accepting the conditions that will be implicit in the provision of financial help from the West and then buying freedom with the wealth that will accrue from the operation of the project.

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Capital Goods and Investment Trends

It has been apparent for some time that the success of a constructive policy of deflation by the Chancellor of the Exchequer under present conditions depends on expanding the output of the right kind of capital goods at the expense of the wrong kind and also at the expense of consumer goods. In concrete terms, the country needs fewer kettles and cotton prints in the home market and more machine tools.

One of the most encouraging, though least dramatic, aspects of Government policy has been the determination to equip itself with a set of capital investment statistics which would enable it to carry out this very exact economic exercise with the comparatively blunt instruments, such as monetary control, at its disposal The recent series of estimates made by the Board of Trade based on the panel of companies making returns on their anticipated investment programme over the next 12 months and their experience in the recent past provides a statistical basis for the policy decisions which have to be taken. At this stage they are comparatively crude statistical tools but they are a beginning and can be improved upon with experience. The latest Treasury *Bulletin* issued deals with the trend of fixed investment and it is clear from this that the Government is able to speak with growing confidence about industrial trends. The *Bulletin* points out that the rapid increase in investment in 1955 played an important part in the renewed onset of inflation. This, in turn, gave rise to the difficult problem of reconciling the long-term need for a higher rate of productive investment with the need to reduce the strain on the economy. Hence the need to boost the right kind of capital expenditure and to stimulate personal savings and reduce personal consumption.

The latest information, based to a large extent on the new investment statistics, shows that the up-swing in industrial investment is going on. Revised estimates show that manufacturing industry expects to spend 20 per cent. more in 1956 on fixed capital investment than in 1955. This figure must be kept in perspective, however. Investment per head in the United Kingdom is now lower than in Germany. There is therefore a long way to go and the fact that capital investment remains buoyant as a whole is a sure sign that the Government's efforts to curb inflation by its present policy will continue. The medicine is working. Its taste may be unpleasant but the economy is going to get further doses of it. As a whole, the engineering industry is fortunately placed for it is marked out to be increasingly stimulated in the struggle to raise output per head and reduce costs.

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More 120 MW Sets

A reflection of the general trend towards power station generating plant of higher unit capacity has been the Central Electricity Authority's announcement last week that two 120 MW turbo-alternators will be installed at Rugeley instead of the four 60 MW sets originally authorised. This is part of a programme covering five new power stations which proposes the substitution of thirteen 120 MW sets for twenty-six of 60 MW. The stations concerned are Rugeley, Staythorpe B, Skelton Grange B, Uskmouth B and Belvedere. Orders for three 120 MW sets for Staythorpe B have been placed already with the Metropolitan-Vickers Electrical Company, Limited. This programme is estimated by the C.E.A. to afford substantial economies in the capital costs of plant and of civil engineering work at the power stations, combined with a considerable gain in thermal efficiency. Turbines for plant of this capacity operate on a reheat cycle, reheating of steam taking place between the high-pressure and intermediate-pressure casings.

The C.E.A. expects to instal few 60 MW machines in future—mainly where circumstances preclude larger sizes. The need for smaller units is likely to be reduced by the developments in recent years in increasing the output from alternators of a given size. Direct-cooling techniques, in which the hydrogen is brought into direct contact with the rotor conductors instead of passing through ducts close to the winding slots, have enabled appreciable reductions in frame size to be made. Outside the 120 MW programme just announced, it will be recalled that Northfleet power station has been planned from the outset for sets of this capacity, three of which are now on order from the G.E.C. Orders have been placed also for plant of higher ratings, such as the three English Electric 200 MW sets for High Marnham, and one of that capacity for another C.E.A. station to be supplied by C. A. Parsons and Company, Limited. All these sets are of the in-line type, but Parsons are also supplying a cross-compound set with two 100 MW alternators in parallel for the Hydro-Electric Power Commission of Ontario. The industry is planning to meet still higher power demands, for at the opening last year of the new heavy turbine shop at the Fraser and Chalmers Engineering Works of the G.E.C., it was stated that there was capacity for building machines up to 400 MW if required in future. The important B.T.H. project for a large turbine works in Northern Ireland is a further sign of preparedness in a field which may in course of time be as important in the overseas market as at home.

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Guided Weapons at Sea

On Monday last the Royal Navy's first guided-weapons trial ship, H.M.S. Girdle Ness, commissioned at Devonport on July 24, was due to put to sea for three weeks' ship trials. The first actual missile trials (without war-heads) are scheduled to commence on September 1 in the Channel. H.M.S. Girdle Ness's main task will be to prove the guided weapons for fleet operation —to assess their "operability" and crew requirements, their reliability and performance, and to gain experience in their handling, maintenance and tactical use. Upon her work, therefore, will be based much of the design of the Royal Navy's guided-weapon ships.

In broad terms, the research and development trials are done on shore, some at the Ministry of Supply Research Establishment at Aberporth in Wales, and some at the Weapons Research Establishment in South Australia. The facilities at these two establishments are complementary; there are some aspects of the work which are best done at one place and some at the other. It has, however, been found from long experience that a weapon system (or a radio, radar, or any other piece of fighting equipment) which works well enough ashore is not necessarily fully suitable for use at sea.

The Girdle Ness has the hull of a Victory-type merchant ship and was built in Canada as a landing-craft maintenance ship. Since October, 1953, she has been completely stripped and reconstructed for her new role in Devonport Dockyard. Her displacement is 10,000 tons, and she has accommodation for 80 officers and 536 men. Her normal naval complement is 33 officers and 360 men. In addition she will carry 20 civilian scientists of the Royal Naval Scientific Service, who will be responsible for the preliminary processing of the telemetered test data, and 30 representatives of the Admiralty, the Ministry of Supply and the firms who have made the equipment, all of whom will be associated with the trials. The firms' representatives will remain on board until the equipment's functioning is thoroughly proved and it is certain that the ship's staff can run it. The guided-weapons equipment consists of radars, display and communications equipment to enable a target to be selected and to control the missiles in flight; magazines and handling gear, hydraulically operated, for stowing and transporting the missiles; and a launcher. In addition, there are elaborate facilities for obtaining data from the trials. Most of the gear is at sea for the first time.

The trials to be done by the ship are planned jointly by the Admiralty and Ministry of Supply in conjunction with all the interested parties. Trials orders are issued to the ship, whose crew has the responsibility of preparing and executing a detailed programme, and of reporting on the results. These results will be analysed mainly by a special team at the Royal Aircraft Establishment at Farnborough, although particular aspects may be analysed by the firms or establishments concerned.

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Lessons of Le Mans

With the victory of a privately entered D-type Jaguar on Sunday, the Le Mans 24-hour race has now been won 10 times by Britain, 7 by France, 6 by Italy, and once by Germany. British support in the form of manufacturers' and private entries, and press and radio coverage on a scale accorded to no other motoring event except the Monte Carlo Rally, has had a large part in establishing this as the world's most important sports car race. Since last year's catastrophe when over 80 people were killed by a crashing car which leapt into the crowd, modifications costing about £250,000 have made the circuit safer for spectators, but not necessarily for the drivers. The new surface where danger spots had been altered proved extremely slippery, and the crashes which eliminated two Jaguars, a Ferrari and an Aston Martin, showed once again that high barriers lining the edge of the track are a certain way of turning a harmless skid into a serious accident.

New regulations have proved useful in limiting speeds and in eliminating freak cars with twin boom bodies, or converted Grand Prix cars with

central driving seats. Prototypes were not allowed to have engines over 2,500 c.c., and only three makes, Jaguar, Aston Martin and Mercedes, were accepted as being production models entitled to use larger engines. More severe restrictions on fuel tank size and frequency of refuelling made it necessary for competing cars to do at least 11 m.p.g. while averaging speeds over 100 m.p.h. This discouraged some from entering, including, it is believed, the Maserati works team, and damage caused by excessively weak mixtures may have been responsible for some engine failures during the race. (There were only 14 finishers out of 49 starters.) However, this restriction may prove useful in diverting attention from sheer speed and acceleration to more useful matters.

The race has been responsible for rapid development in brake design. The Jaguar disc brakes this year apparently had friction pads which could be changed in 30 seconds. Such quick replacement would allow a higher rate of lining wear to be accepted on private cars, and could permit more vigorous use of the brakes, which is certainly the easiest way to higher average speeds in mountainous country. Unfortunately, the Le Mans circuit makes little demand on suspension, or even on tyres.

New regulations requiring bodies with two doors, full-width windscreens and wider seats, meant that Le Mans had to be excluded from this year's world sports car championship, but the organisers' initiative in favour of a more practical type of car has been successful, and international regulations covering other races will be brought into line for 1956. The full-width windscreen adds 2·1 sq. ft. to the frontal area, and the minimum height of 8 in. is not popular with drivers, who find an electric wiper quite useless in rain at speeds of 150-180 m.p.h. and prefer to see over the top of the screen. However, there is as yet no sign of a reversion to streamlined closed bodywork. The modern "open" sports car has a low drag; Jaguar ingeniously reduced the wind resistance of the new windscreen by fairing it into the driver's head-rest and tail fin at one side, and using a transparent cover over the passenger's seat to make a fairing attached to the top of the screen so minimising eddies at the other side.

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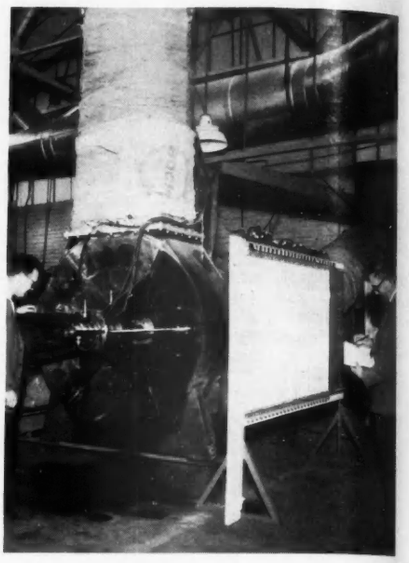
Atom Groups Prepare to Tender

On October 1, the four main industrial atomic energy groups are due to submit their tenders for the Bradwell and Berkeley nuclear power stations. Meanwhile each group is engaged on the development studies, research and planning which must precede the preparation of an estimate. The English Electric Company, which for this purpose is associated with Babcock and Wilcox Limited and Taylor Woodrow Construction Limited, have published some details of their atomic energy work, and the range of new equipment that has been installed at their Whetstone premises, the number of experimental test rigs that have been erected, and the long hours of overtime being worked by scientists and technologists are some indication of the effort being made.

The Whetstone plant of the English Electric Company, which was originally built by the Government for Power Jets Limited, is not restricted to atomic energy work, but also includes a gas-turbine department, mechanical engineering, metallurgical and chemical laboratories, and various manufacturing shops. Although English Electric are now of course concerned primarily with the Calder Hall type of reactor, it seems possible that the association on the same premises of gas turbine and atomic energy departments may lead in the future to the development at Whetstone of the close-cycle gas-turbine reactor system.

At present, however, atomic energy research at Whetstone is applied to gas-cooled reactors with secondary steam circuits. Some of the studies in hand are related to the design of uranium fuel elements, fuel handling equipment, methods of containing the growth of the graphite moderator in a pile, and the control of reactor heat output. There is an extensive air-conditioned creep-testing laboratory for investigating the properties of materials under the temperature and stress conditions likely to be encountered, and a simulator has been built to represent the kinetic behaviour of a reactor in operation. Other equipment is used to check the thermal conductivity between two dissimilar materials—a problem that arises in fuel-element canning—and to examine the characteristics of blowers used for circulating carbon dioxide in a reactor; an illustration on this page shows a half-scale single-stage blower under test.

Dr. H. S. Arms, project manager of the English Electric atomic power department, has said that the group would quote a fixed price for a complete installation, though this was not the practice with orthodox stations. The reactors will probably be larger and steam pressures higher than at Calder Hall. The other groups competing are the A.E.I.-John Thompson Nuclear Energy Company, the Nuclear Power Plant Company (C. A. Parsons, Reyrolle and Head Wrightson), and the G.E.C.-Simon-Carves group. The chances of success are considerably enhanced by the contention, rumoured to be the view of the United Kingdom Atomic Energy Authority, that no one group has sufficient capacity to build more than one station. Bradwell and Berkeley provide sites for two stations, a third is likely to be required in Scotland; thus if Japan does in fact order a nuclear station the four groups are betting on a certainty.



Half-scale blower for carbon dioxide reactor coolant under test at the English Electric Whetstone plant. (See "Atom Groups Prepare to Tender.")

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Single-Wheeler

The model locomotive illustrated on this page has recently been installed in the Hall of Power of the Royal Scottish Museum, Edinburgh. Mr. Robert W. Plenderleith, assistant keeper in the Technological Department, says that it may revive fading memories among those old enough to recall the single-wheelers of the Caledonian Railway. The model has been made by the Museum's craftsmen and is to a scale of 1 inch to the foot. Overall, the engine and tender measure almost 4 ft. In the illustration the front left-hand cylinder cover appears to be jutting out into space without a complete cylinder; the model is partly sectioned on that side to reveal internal details.

The "Connor singles" had 8 ft. 2 in. driving wheels and worked the fastest passenger and goods train on the Caledonian Railway's main line. Mr. Plenderleith says that although the design is attributed to Benjamin Connor, locomotive superintendent of the railway from 1856 to 1876, the design is basically the same as that of the Crewe-type engine which was designed by Alexander Allan and that there is little doubt that Allan had a hand in the design if, indeed, it was not entirely his own. Because of the high driving axle it was difficult to ensure a reasonably low boiler centre line. A Gooch fixed-link valve gear was therefore employed, with depressions in the underside of the boiler to accommodate the throw of the eccentrics. Twelve of these engines were built up to the year 1863 at the St. Rollox Works. Four more engines, with slight modifications, were built in 1875. The model is of engine No. 76 (which was built in 1859, and re-built probably about 1862) and was constructed in 3½ years, though at times the craftsmen were also working on other jobs. The cylinders, instead of being cast as is usual in full-size practice, were fabricated, so that accuracy of dimension and finish could be more readily achieved. The wheels were cut from the solid on a milling machine and thereafter finished by hand

New model of an old locomotive for the Royal Scottish Museum. (See "Single-Wheeler.")

ENGINEERING CONTRACTS

1—THE PITFALLS OF TENDERING

By F. H. B. Layfield

The first of a series of about 10 *advisory articles on the law of contracts. Mr. Layfield has written the articles for engineers and others concerned with engineering contracts. Editorial comment will be found in Plain Words, page* 130.

Agreement is the underlying basis of the whole conception of contract. The process by which the law recognises that a contract has been made is that of *offer* and *acceptance*. An offer which can be converted into an agreement must consist of a definite promise to be bound, provided always that certain specified terms are accepted. This offer then leaves to the other party his share in the process, which is the acceptance or refusal of the promise. It is, however, important to remember that both offer and acceptance must be in identical terms; there is no agreement if the acceptance introduces new terms which the offerer has not previously included, for this is merely a counter-offer and not an acceptance at all.

These broad propositions are the background against which the tendering stage of any engineering contract must be considered. This stage usually commences by the invitation to tender. The invitation, whether made by advertisement, notice or letter, is not an offer. As Mr. Justice Wills said:

> " It is a mere attempt to ascertain whether an offer can be obtained within such a margin as the sellers are willing to adopt."

The offer is the submission of the tender itself, and the exact terms of this offer are all important. The tender which constitutes the offer is often based upon the standard forms of contract now in widespread use. Sometimes the process is simple: the tenderer fills in a standard form of tender accompanied by the usual technical documents duly completed and he agrees therein to be bound by the appropriate set of standard conditions. If the engineer or the purchaser then accepts without reservation there is little or no difficulty. Often, however, this is not the case and difficulties arise. These difficulties usually result from discussions and negotiations which vary the basis of agreement.

The most common of these difficulties and the one most easy to avoid is that caused by additions, deletions or alterations made to the standard documents when the tender is submitted. The " Memorandum as to Tenders " appended to some standard forms needs to be regarded with special caution in this connection. Some of these memoranda state: " The tenderer is at liberty to add any details and conditions that he may deem desirable . . ." This of course is true. Naturally the tenderer may make an offer in any terms he likes since the invitation does not bind him; what will bind him is the tender if it is accepted. One such memorandum continues: " In the event of his doing so he must annex the added matter to the specification or General Conditions returned by him . . ." This is wise advice so far as it goes. The tenderer cannot be too careful to ensure that alterations he makes to the standard forms are clear.

Finally, the same memorandum says that: " . . . any such additional details and conditions will not be binding on the Purchaser unless they are approved by him and incorporated in the Contract." This advice should be treated with reserve, since it begs many vital questions.

If the Tender, with clearly indicated variants to the specification or general conditions, is sent to the employer or purchaser then those documents as they stand constitute the offer. If that offer be accepted, either in writing or by conduct without more ado, what the engineer or employer has accepted is the offer *as it stands*. Nowhere is this position more plain than in the Form of Tender annexed to the Institution of Civil Engineers' Conditions of Contract, which states:

> " Unless and until a formal Agreement is prepared and executed this Tender, together with your written acceptance thereof, shall constitute a binding contract between us."

This acceptance is not necessarily confined to embracing those changes caused by additions or deletions. The memorandum already quoted also points out that:

> " If the tenderer has any doubt as to the *meaning* of any portion of the General Conditions or of the Specification, he should, when submitting his tender, set out in his covering letter the interpretation upon which he relies."

The engineer should appreciate that if the tenderer follows this rather singular advice, and states the meaning he contends for, then it is almost certain that, for the purposes of the contract, the relevant portion will have the tenderer's meaning, for it is upon that condition, among others, that the offer is made. If the tenderer seeks to place a particular interpretation upon a part of the specification then clearly the engineer is the best person to decide upon acceptance or no. On the other hand it is probably unwise for him to accept any interpretation of the meaning of any part of the General Conditions without proper advice, and if he does he may regret it. A special meaning given to a particular word in one clause may seem reasonable enough. It is when the effect of that clause or word is seen in its relation to other provisions of the contract that difficulties arise.

These additions, deletions or interpretations may, not unnaturally, cause the engineer to be unwilling to accept the offer. If he rejects the offer out of hand there is an end to the matter. More usually, however, he will wish to negotiate. It is in these circumstances that the most common difficulty arises. This is well illustrated by a recent case before the House of Lords. In *Davis Contractors Ltd.*, v. *Fareham Urban District Council* the contractors had entered into a building contract to build 78 houses for £85,836 within a period of eight months. They attached to the form of tender making their offer a letter which said, among other things:

> " Our tender is subject to adequate supplies of material and labour being available as and when required to carry out the work within the time specified."

The position which arose as a result of this letter was described by Lord Simmons:

> " It is possible that, if this letter had been followed by an immediate acceptance, the parties must have been deemed to enter into a contract which contained some such term, though its precise content and effect would have been extremely difficult to define. But that is not what took place nor what might be expected to take place. On the contrary, there were negotiations following the tender and these resulted in the formal agreement of July 6, which did not incorporate the letter of March 18. It would, as it appears to me, be contrary to all practice and precedent to hark back to a single term of preceding negotiations after a formal and final agreement had been signed."

Clearly, where the tender or accompanying documents contains important stipulations these must be carefully watched. Where such a tender is the subject of immediate or early acceptance, then the conditions of the offer contained in the tender will usually constitute the conditions of the contract. Where there are intervening negotiations then the conditions of the contract must be ascertained by looking at the final agreement. Therefore, after negotiations have been conducted all parties should take unusual care to ascertain that all the relevant stipulations to which the parties have agreed are included in the final document either directly or by express reference. Perhaps the most convenient and satisfactory way in which this can be done is by means of a letter from one party to the other which sets out the agreed variations on the original offer. This letter can then be incorporated in the contract by including it in the clause which specifies the contract documents.

Two further matters call for attention in this same connection. As Lord Simmons observed in the Davis case, even where a covering letter or similar document in fact forms part of the contract there sometimes remains the problem of what it means. It is by no means infrequent to find that these additions or alterations are capable of having a number of different meanings, which, of course, will often remove their value. Those who add or insert such additional material will be well advised to consider not only whether the matter in question seems to mean what they desire it to mean, but, more especially, if it *can* bear any other meaning. Additions, deletions and alterations also must be watched for inconsistency. When negotiations have taken place over a long period of time, changes are agreed at intervals. In these circumstances, it is fairly easy for a late change to be inconsistent with an earlier change in the offer. Accordingly at the end of negotiations it is valuable to spend some time reviewing all the variations agreed with an eye to their compatability.

SUMMARY

The tenderer is not bound in any way by the receipt of an invitation to tender. He is free to put in to the engineer whatever offer he thinks fit to make. Of course the engineer or employer may warn the tenderer in advance that tenders of a certain kind containing or lacking a particular provision will not be accepted. But such a warning is no part of the actual offer made. The tender itself is the offer and it is that which must be examined to see what the tenderer has undertaken to do if his tender is accepted.

(*a*) If the tender is accepted either in writing or by conduct, then the offer is accepted, warts and all. In particular it will be useless to complain in such circumstances that it should not contain, or fails to contain, some particular stipulation or condition.

(*b*) If the tender is rejected and it is later desired to proceed then there must, of course, be a new offer, although the latter may, if so expressed, incorporate an earlier tender.

(*c*) If riders are added to the standard form of tender or deletions are made it will often be important to decide upon the precise effect of such changes. If the tender to which these changes relate is the subject of early or immediate acceptance then it is likely such changes will be held to be incorporated in the contract. If acceptance takes place only after discussions and negotiations then it will normally be necessary to look to the final document to find the terms of the contract.

(*d*) Even when additions have been made to standard forms and these are incorporated in the contract, their effect is not always easy to ascertain nor their meaning clear. Riders of this kind call for careful and unambiguous drafting and it should always be asked whether they will be consistent with other provisions of the contract, and indeed with other riders. At the receiving end they need to be read and examined with at least equal care to ascertain exactly what is being accepted or rejected. Especially is this process necessary when the tenderer sets out an interpretation on which he relies of the conditions of the contract.

Much of what has been said here is perhaps obvious, and much is commonsense. Nevertheless, these aspects of contract are frequently overlooked or ignored, often with costly results. One hour spent in checking at the formative stage will save many hours later. That stage is the tendering process which will create the agreement on which the whole contract depends.

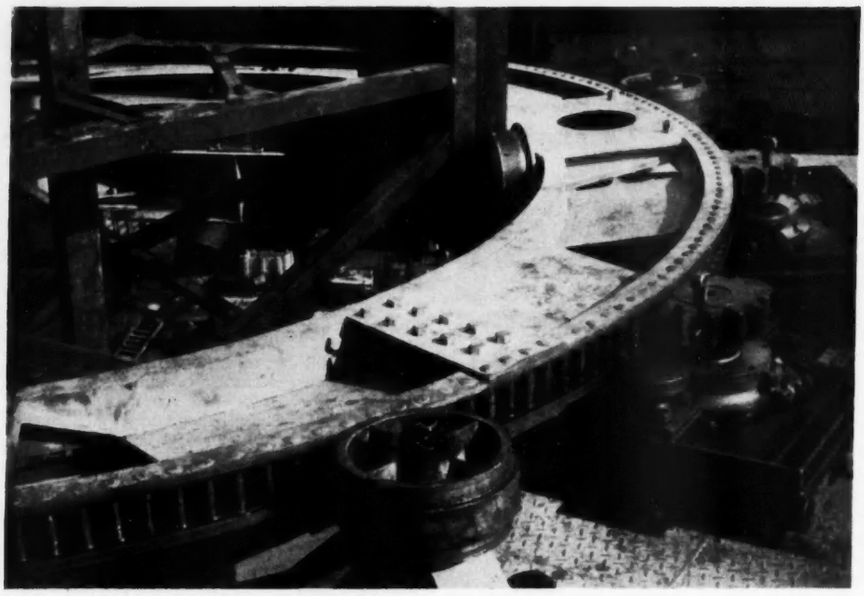


Fig. 1 Arrangements of a typical lantern-wheel drive; when worn, the pins are cheaply replaced.

LOW-COST SLOW-SPEED DRIVES

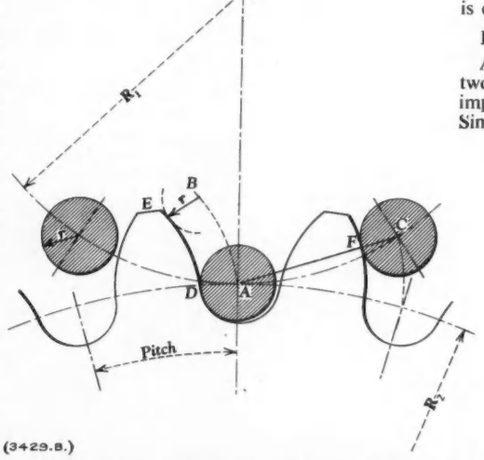
"LANTERN WHEEL" GEARING

By W. H. Mann, B.SC.(ENG.), A.M.I.MECH.E.

Although conventional gear drives with a standard involute tooth profile are quite economical for most cases of gear designs, lantern wheel drives are frequently employed for their reasonable manufacturing costs where large slow-running gear wheels are required (Fig. 1), or for cases of stationary circular racks. Lantern wheel gearing has certain shortcomings, but perhaps one may express the view that the ideal design of a particular piece of machinery is not necessarily the most desirable one when considering such points as cost of production, manufacturing process and upkeep. The best design is that which is the least complicated and most economical one that will perform a particular operation satisfactorily.

As far as the designer is concerned the basic consideration is that of choosing the right analysis, applying methods which will give with sufficient accuracy the loads and stresses of the particular part under actual service conditions. It is therefore necessary for him to know the limitations and reliability of analytical methods. No advantage is derived from highly accurate stress calculations when it is difficult to assess precisely in what manner a load is distributed over a certain part of a member under working conditions. The methods applied below are therefore only as accurate as is generally necessary; more exact but less simple calculations are possible.

To understand the mechanism of lantern-wheel gearing the following considerations may be helpful: for the lantern wheel the diameter of the rolling circle is equal to that of the pitch circle and the tooth profile reduces to a point, while the tooth profile of the pinion is shaped according to curve AB (Fig. 2) which theoretically is part of a cycloid. It owes its suitability to the fact that the line joining the tracing point C to the point of contact A of the rolling circle and the line along which it rolls is normal to the cycloid. This will be clear when considering that at any instant A is the instantaneous centre about which the rolling circle turns and C, the tracing point on the circle, will therefore move at this moment along a line which is perpendicular to CA. In practice the point-tooth is enlarged into a pin of a certain diameter and profile AB is replaced by the equidistant profile DE. The profile will be hypocycloidal for an internal wheel drive and epicycloidal for an outside one. The correct engagement of profile DE with a lantern-wheel pin does not take place when the centre falls on the centre line OA but only when the tooth profile arrives there. Prior to this position the normal to the tooth profile at the point of contact does not pass through A. It can also be seen that the point of contact moves away from the pitch circle, moving to point F on AC which is normal to the profile curve at the point of contact.



(3429.B.)

Fig. 2 In theory, the lantern-wheel tooth is a point, and the pinion-tooth profile, obtained by rolling the lantern-wheel pitch circle over the pinion pitch circle, is part of a cycloid AB. In practice the point tooth is enlarged to a pin of radius *r* and the cycloidal tooth profile is displaced to DE, parallel to AB and a distance *r* from it. The bottom of the tooth space is semicircular and allows a clearance on the pin diameter.

In order to obtain smooth running each pin of a wheel should not lose contact with the corresponding tooth of the pinion before the next pin and tooth have come into engagement. In practice, therefore, the addendum circle of the pinion is made a little larger than that theoretically required and the number of teeth of the pinion not less than nine.

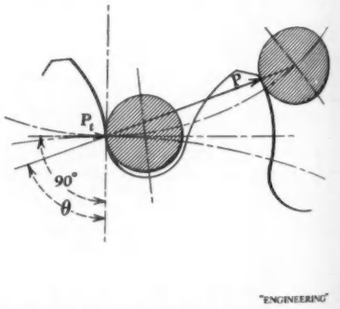
When the point of contact of a pin and tooth falls on the line of centres of the two mating gears the common normal of the profiles will make an angle of 90 deg. with the line joining the centres (as shown in Fig. 3), and the tooth load P will be equal to the circumferential force P_t. As the pin moves from the pitch point towards the tip of the tooth the line of thrust alters in direction, i.e., θ becomes smaller and the tooth load increases since P is related to P_t by the expression $P = \frac{P_t}{\sin \theta}$. It follows that friction and wear must increase also as the pin moves over the face of the tooth and its profile will wear down after a period of running. Depending on the relative wear-resisting qualities of the materials employed the pins may suffer even greater wear than the pinion teeth. This will be appreciated when considering that only a very small part of the pin circumference is in contact with the tooth, whereas the whole length of the tooth is used.

After wear of both tooth and pin has taken place, the velocity of the driven wheel falls off gradually as the pin moves from the pitch point to the tip of the tooth and an abrupt engagement results when the following pin commences its load-bearing contact on the pitch line which is the little-worn part of the tooth. This is a shortcoming of lantern-wheel gearing and a reason why it is suitable for comparatively small pitch-line speeds only. It should be born in mind, however, that it is impossible to form any type of gear tooth with mathematical precision, whether involute or cycloidal, and variations of velocity ratio will take place. Successive engaging pairs of teeth may consequently enter into load-bearing contact more abruptly than desirable, and its extent will naturally depend on the accuracy of the tooth profile that can be obtained.

The profile of the pinion tooth may be obtained by rolling the pitch circle of the lantern wheel on the pinion pitch circle, when a point on the former will trace out the required locus AB. The bottom of the tooth space is semicircular; it is proportioned to give the pins sufficient play and to allow for inaccuracies in wheel centres. A reasonable clearance would be about 10 per cent. of the pin radius. It may be added that the working part of the tooth is only that part outside the pitch circle.

DESIGN FOR WEAR AND STRENGTH

As far as lantern-wheel gearing is concerned two design considerations are of considerable importance, that for strength and that for wear. Simplified design calculations are presented below



"ENGINEERING"

Fig. 3 Since the load on the pinion tooth $P = \frac{P_t}{\sin \theta}$ increases as the pin moves from the pitch point towards the tip, the profile of the tooth tends to wear more rapidly towards the end of the flank, and may hollow-out after a period of running.

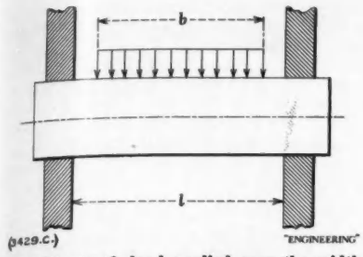


Fig. 4 The tooth load applied over the width b of the pinion imposes a bending moment on the pin which has a clear span l.

which will enable the designer to determine the right gear proportions with an accuracy quite adequate for the type of gear discussed.

Let b = width of tooth face (in.);
f_b = bending stress (tons per sq. in.);
HP_s = horse power for strength;
HP_w = horse power for wear;
K_s = specific stress for strength (lb. per sq. in.);
K_w = specific stress for wear (lb. per sq. in.);
N = number of revolutions of pinion;
p = circular pitch (in.);
P_s = permissible tooth load for strength per inch of tooth width (lb. per in.);
P_w = permissible tooth load for wear per inch of tooth width (lb. per in.);
t = number of teeth in pinion;
U = ultimate tensile strength (tons per sq. in.);
Z = modulus of section (in.^{3}).

Experience has shown that it is insufficient to design gear teeth merely for strength, i.e., for maximum bending and direct stress at the root of the tooth. It is necessary also to consider the surface pressure between mating teeth, which if permitted to exceed certain limits may lead to rapid wear and reduce the lifetime of the teeth correspondingly. Formulae for wear are based on the Hertz equation which gives the stress set up between two spherical surfaces as a function of the load, the moduli of elasticity, and the curvature of the faces in contact. In arriving at the simplified formula below, the shape of the tooth form was taken into consideration as well as the principal factors influencing wear, i.e., speed, total running time, and the material employed. The steps leading to this expression are outside the scope of this article and they have therefore been omitted. To facilitate the determination of the permissible load for wear without there being any need to look up "dozens" of charts and tables, the aforementioned factors have been combined on a single nomogram from which, with one setting of a cross-line cursor, the permissible specific stress for wear is obtained.

The permissible load per unit width of tooth, in lb. per in., is then limited by wear according to the following expression:

$$P_w = K_w p \quad . \quad . \quad (1)$$

and the permissible horse power is limited to:

$$H P_w = \frac{P_w b p t N}{396000} \quad . \quad . \quad (2)$$

For a first approximation the width of the tooth may be taken as $1\frac{1}{8}p$ which will then give the horse-power expression as

$$H P_w = \frac{K_w p^3 t N}{352000} \quad . \quad . \quad (3)$$

Gear teeth must be checked for adequate strength although wear on the mating surfaces is usually the more important factor in gear design. A formula similar in structure to that for wear has been developed. The permissible load per unit width of tooth, in lb. per in., is limited by strength according to the expression

$$P_s = K_s p \quad . \quad . \quad . \quad (4)$$

As before permissible horse-power is limited to

$$H P_s = \frac{K_s b p^2 N t}{396000} \quad . \quad . \quad (5)$$

For a given material, gear calculations are based on the number of revolutions per minute as this takes into account the magnitude of the load and stress repetitions which influence strength and wear of the mating teeth. For the case of two mating gears the pinion is always running at the higher speed and thus the pinion becomes generally the governing factor in gear design. It is good practice therefore to employ a somewhat higher grade material for the pinion than that for the lantern-wheel pins; the pins are merely checked for their strength as a beam.

The maximum bending stress of the rack pins must not exceed the recommended safe stress for the particular material, paying due regard to the nature of the applied load, and one may write

$$f_b = P \frac{\left(\frac{l}{2} - \frac{b}{4}\right)}{2Z} < \frac{U}{6}, \text{ say} \quad . \quad (6)$$

where l is the clear beam span of the pin (see Fig. 4).

USE OF NOMOGRAMS

The method of using the nomograms is demonstrated in the following example.

The pinion of a lantern-wheel drive is to run at 20 r.p.m., the number of teeth is 9 and a pitch of $2\frac{1}{2}$ in. has been assumed. The width of the pinion has been fixed at 3 in. and it is expected to run for a minimum of 5,000 hours.

The material chosen for the pinion is a "50" carbon steel with a minimum ultimate tensile strength of 45 tons per square inch and a corresponding Brinell hardness number of about 200; that for the rack pins is a "40" carbon steel with a minimum ultimate tensile strength of 35 tons per sq. in.

To find the specific stress, place a cross-line cursor—suitably made by drawing two perpendiculars on a piece of tracing paper—on the nomogram for wear (Fig. 5) so that one line cuts the 200 mark on the B-scale for forged steels and the 20 mark on the N-scale. Shift the cursor along this line until the perpendicular cross-line cuts the 5,000 mark on the T-scale. The allowable specific stress for wear, 830 lb. per sq. in., is read off the K_w-scale. The permissible load for wear according to equation (1) is then

$$P_w = 830 \times 2{\cdot}5 = 2{,}075 \text{ lb. per in.}$$

Using the cross-line cursor in a similar fashion but on the nomogram for strength (Fig. 6), the specific stress for strength, 1,360 lb. per sq. in., is read off the K_s-scale.

The permissible load for strength according to equation (4) is then

$$P_s = 1{,}360 \times 2{\cdot}5 = 3{,}400 \text{ lb. per in.}$$

Wear is obviously the governing factor and for a pinion width of 3 in. the total permissible load will be $2{,}075 \times 3 = 6{,}225$ lb.

Suitable dimensions for the rack pins will be $1\frac{3}{16}$ in. diameter with a clear beam span of about $3\frac{3}{8}$ in. Checking for strength it is found

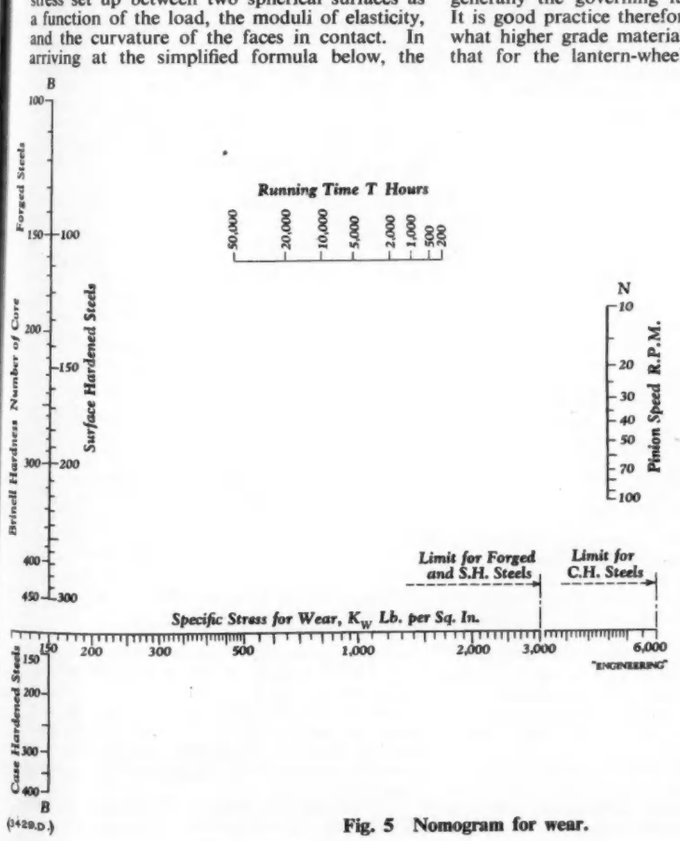


Fig. 5 Nomogram for wear.

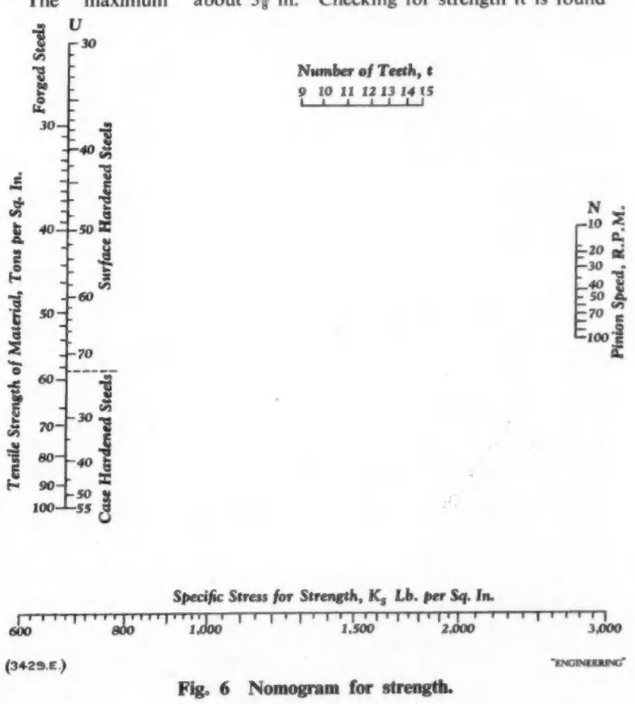


Fig. 6 Nomogram for strength.

that, according to equation (6),

$$f_b = \frac{6{,}225\left(\frac{3{\cdot}375}{2} - \frac{3{\cdot}0}{4}\right)}{2{,}240 \times 2 \times 0{\cdot}225} = \frac{6{,}225 \times 0{\cdot}938}{2{,}240 \times 2 \times 0{\cdot}225}$$

$$= 5{\cdot}78 \text{ tons per sq. in.} < \frac{35}{6}$$

which is satisfactory.

HORSE POWER RATING

The safe horse power according to equation (2) is

$$\text{H P}_w = \frac{6{,}225 \times 2{\cdot}5 \times 20 \times 9}{396{,}000} = 7{\cdot}0, \text{ say.}$$

Alternatively, in cases where the horse power, the speed and material of the pinion have been fixed and it is required to find a suitable pitch one may conveniently proceed as follows :—

Employing equation (3) and using the same figures as in the above example evaluate

$$p^3 = \frac{7 \times 352{,}000}{20 \times 9 \times 830} = 16{\cdot}5.$$

$$p = 2{\cdot}55 \text{ in.}$$

The nearest standard pitch is $2\frac{1}{2}$ in. and $\text{P}_w = 830 \times 2\frac{1}{2} = 2{,}075$ as before. Substituting this value in equation (2) and transforming the required face width for the teeth is obtained.

$$b = \frac{7 \times 396{,}000}{2{,}075 \times 2{\cdot}5 \times 9 \times 20} = 2{\cdot}965,$$

say 3 in. wide.

The pinion and rack pins are then checked for strength as before.

Concluding, it may be briefly added that when choosing a suitable material the question of cost, ease of machining, its reaction to heat treatment and behaviour during service should be considered carefully.

It will be appreciated that a case-hardened pinion, if it meshes with rack pins of comparatively soft material, should be well ground after heat treatment. If this precaution is omitted the rough teeth of the pinion will quite rapidly ruin the softer mating pin material. Experience has also shown that case-hardened steels do not always work well with oil-hardened steels. Generally, a steel with a carbon content of 0·4 to 0·55 per cent. in the normalised condition is quite a good pinion material with adequate toughness and wear-resistant qualities. Regarding the group of case-hardened or surface-hardened steels it may be mentioned that it is not sufficient to have a very hard wear-resisting surface alone; the core must also be strong enough to support the case. In cases where the gear has to withstand shock loads or similar severe service conditions it may be better to use a medium carbon alloy, air, oil or water-hardened steel with a good core strength rather than a plain carbon steel that has been case hardened.

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GAS TURBINE ROTORS LIQUID COOLED

SOLAR AIRCRAFT COMPANY'S DEVELOPMENT WORK

At the American Society of Mechanical Engineers Diamond Jubilee Annual Meeting, Mr. R. E. Grey and Mr. D. D. Drake, of the Solar Aircraft Company, presented a lecture on "The Application of Internal Liquid Cooling to Gas Turbine Rotors." We give below an abridged version of their written paper.

SHIPBOARD APPLICATION

Early in 1951, Solar Aircraft Company initiated a development programme to produce a long-life gas-turbine power plant primarily for shipboard use. The design was to be based on materials having less than 5 per cent. strategic alloying material and the complete elimination, if possible, of cobalt, columbium, and beryllium; the turbine rotor was to be liquid-cooled with a closed cooling system, and the stationary parts to be cooled by air or by liquid; the overall plant efficiency of the liquid-cooled turbine power plant was to equal or exceed the performance of the Jupiter T-400J unit, and the designs were to be based on the use of the existing T-400J compressor. It was decided to use three turbine stages for the T-500J, as it is designated, instead of the two stages in the T-400J unit. A design point was set with a turbine inlet temperature of 1,750 deg. F. Forced convection was adopted in preference to free convection or combined techniques for rotor heat transfer, and water was selected as coolant fluid because of its very high thermal conductivity, general availability, and cheapness.

MATERIALS

The materials selected were almost all of the ferritic alloy group, and protection was obtained by means of coatings and inhibitors. All the highly stressed parts were designed to operate below 800 deg. F. For these applications, alloys currently in use in conventional aircraft gas-turbine structures at similar temperatures have been specified. For the rotor blades, a high-temperature bolting steel containing chromium, molybdenum and vanadium was selected.

Parts subjected to direct impingement of combustion gases were protected by diffused chromium coatings. The process, known as chromising, results in a coating of about 0·001 in. thick, having about 70 per cent. chromium at its surface. Samples of this coating, when subjected to high-temperature oxidation tests in a furnace as well as hot-gas erosion tests, had shown very good results. The electro-less nickel plating was used on machined surfaces, and silicone-base aluminium paint was applied to sheet metal parts.

With water as the coolant, difficulty was expected from corrosion of the low-alloy iron-base metal parts in contact with the fluid. To minimise deposits from the coolant, distilled water was to be used; and to inhibit corrosion, sodium chromate in concentrations approaching 5,000 p.p.m., was specified.

BLADE DESIGN

The test programme envisaged the preliminary operation of the first stage to check the theoretical approach used in the design.

For the length-to-diameter ratios approaching 20 to 1, with a $\frac{1}{16}$ in. diameter hole, the coring of such holes for casting was not practical, and it was necessary to drill the blades. A design was evolved based on the use of a precision-cast blade having a cavity in the tip. The configuration adopted for the first-stage rotor blades, which were solid blades with six radial coolant holes, is shown in Fig. 1.

Coolant holes were drilled from the tip cavity to the base, and interconnecting holes were drilled in the forward and aft faces of the base to serve as manifolds. An inlet hole and a return hole were drilled into the bottom of the blade to the connecting manifolds. This configuration required that the cavity at the top of the blade and the two manifold holes in the base be capped. High-temperature brazing techniques were selected for this job.

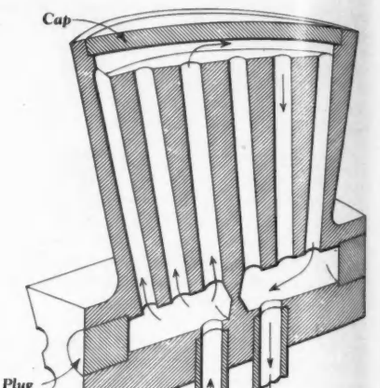

Fig. 1 Cut-away view of the solid-section first-stage rotor blade, showing drilled radial cooling passages and connecting manifolds.

SINGLE-STAGE TEST TURBINE

A layout drawing of the single-stage test turbine is shown in Fig. 2. The inlet stator vanes were fabricated of low-alloy sheet metal and were air-cooled. The rotor was straddle-mounted between a duplex ball bearing on the forward side and a roller bearing on the aft side. Such straddle-mounting was selected in order to support the overhung shaft which contained the necessary coolant inlet and outlet passages as well as connections for transferring the rotor thermo-couple readings so that blade temperatures could be measured during operation.

The configuration adopted for the turbine inlet scroll was a dual-walled unit having insulation between the walls, the outer wall carrying the pressure load and the inner wall being pressure-balanced and thus carrying only its own structural weight. In this configuration, the inner wall functions primarily as a sheath to protect the insulation.

Heat transfer to the outer wall is limited by the internal insulation, and heat is removed from the outer wall by natural convection. A maximum operating temperature of about 800 deg. F. was expected for the outer wall, and that unit was fabricated from mild steel. For the inner member, which would run at gas temperature, 1,750 deg. F., AISI 502 with a chromised coating was specified.

AIR-COOLED STATORS

The inlet stator vanes were fabricated of 0·025 in. thick sheet stock with 0·010 in. thick "marcel" inserts brazed on their inside surfaces. Twenty of these vanes were welded into the shroud ring forming the inlet stator. The turbine casing was supported independently of the inlet stator vanes by means of struts, which passed through the vanes and were welded into inner and outer rings. The inner ring was clamped to the forward bearing housing and the outer one to the turbine casing.

The rear bearing housing was supported by air-cooled vanes, but the vanes at this station were welded into the inner and outer shrouds, which became part of the structure. It was originally intended that the struts in the inlet stators, as well as the exit vanes, would maintain bearing alignment; but after preliminary tests revealed inadequate rigidity, an external pedestal system was added.

Arrows indicating the cooling air flow path are shown in Fig. 2. The cooling air enters from a

supply manifold around the turbine casing and passes down the trailing edge of the stator vanes through the transfer space between the inner shroud ring and the bearing housing, up the leading edge of the stator vane, and then discharges into the manifold outside the turbine casing. Cooling air also enters from the manifold and flows over the turbine shroud into the exit vanes and is discharged at the inside of the exit scroll.

ROTOR COOLANT SYSTEM

For a practical gas turbine interchangeability of rotor-blades is highly desirable. This introduced a major problem of sealing each blade to the wheel, both where the coolant entered and where it returned to the closed system.

The design tested in the single-stage turbine utilised a disc split in the radial plane with conventional axial fir-tree slots to retain the blades. Cooling fluid was supplied to each blade from a housing located in the centre of the split wheel and the cooling fluid was returned to the same housing. Connection between the blade and the housing was by two $\frac{1}{8}$ in. diameter tubes which were brazed into the blade. Sealing was accomplished by means of O-rings where the tubes entered the housing. The six bolts that held the split rotor together passed through the housing, clamping it between the rotor discs.

The two halves of the split rotor had shafts welded to them. The forward shaft was solid and carried the duplex ball bearing. The aft shaft was supported in the roller bearing and carried the coolant transfer devices as well as the rub rings for the coolant seals. The aft shaft had a $\frac{1}{2}$ in. diameter hole in its centre which carried the thermocouple lead wires. In addition to this central hole, eight $\frac{1}{4}$ in. diameter holes were drilled axially into the shaft; four for coolant supply and four for coolant return.

The rotor coolant flow system is also shown in Fig. 2. The fluid was stored in an external tank and a pump delivered it to the turbine casing. Face-type seals mounted in the casing prevented leakage of the coolant as it entered the rotating shaft. The four axial supply holes discharged into the centre of the coolant housing within the wheel and the fluid was collected in an annular passage. From this passage it flowed radially outward through six holes located between the rotor bolts and into an outer annular passage from which it was distributed to the blades via the supply tubes. The return system was similar; the annular passages and radial holes for this system being located alongside the corresponding supply passages. The returning coolant flowed through the shaft and was discharged into an area in the aft casing which was sealed with face-type seals and was collected from this part of the housing and piped through a heat exchanger back to the tank.

During 200 hours testing of the single-stage unit only two forced stoppages occurred due to the turbine design. The first occurred when the rotor stationary shroud warped and rubbed on the rotor. This shroud was a continuous band and it was merely re-machined to provide the original clearances. The other failure occurred while the unit was running at a speed of 20,000 r.p.m., and a gas temperature of 1,000 deg. F. An emergency shutdown was required when the operators noticed that the coolant flow rate increased suddenly. One of the tip caps had come loose from a blade, and subsequent study of that blade showed that the penetration of the braze into the joint was generally inadequate. Newer brazing techniques have been adopted which indicate substantially sounder joints, and, in addition, the tip cap has been re-set, so that when the rotor diameter is ground, a substantial portion of the braze fillet remains.

Air-cooling of the stators was generally unsatisfactory because of the leakage of cooling air into the gas stream and the high pressure drop encountered in the system. With indications that higher pressure air may be required, liquid-cooling of the stators now appears to be more attractive.

During a 100 hour endurance test at 1,700 deg. F., it was found necessary to replace the inlet elbow liner, which was of low alloy, after that unit buckled and allowed the hot gas to impinge on the outer wall of the scroll. This occurred after about 58 hours of hot operation. In addition, the extreme aft coolant seal leaked badly during the 100 hour test and had to be replaced at 21 hours and again at 68 hours. The other two coolant seals were in good condition. During all the operation of the single-stage turbine, no vibration difficulties were detected.

During the 100 hour test, the combustor liner was checked and found to have accumulated carbon deposits. These were cleaned off but it was found that they accumulated again in a very short time. Apparently they did not affect the operation of the combustor. The majority of the carbon collecting at the dome was due to reverse-flow out of the dome. A new combustor has been developed which utilises a shrouded dome to assure a positive penetration of air.

At the end of the 100 hour run, the coolant flow rate was measured and compared with the initial flow rate. It was found that there was very little reduction in the internal flow rate.

STRIP REVEALS LITTLE CORROSION

After the completion of the 100 hour test, the unit was stripped and inspected. The combustor unit which had been cleaned at 61 hours was found to be coated with carbon. After cleaning, however, it was noted that most of the ceramic coating on the outside was in very good condition. Some localised overheating had occurred due to the distortion of the film-cooling slots in between spacing dimples.

The interior of the machine was generally dirty, due to the combined leakage of oil and coolant. During the tests, coolant leakage rates of less than 3 gallons per hour were normally maintained. Coolant that leaked into the machine evaporated and left a green deposit from the chromate inhibitor that had been added to the water. The rotor blades themselves were covered with a combined oil and chromate deposit and upon cleaning it was found that they were in very good condition with no signs of corrosion or erosion, and damage was limited to some small nicks caused by the passage of foreign particles through the machine. As was noted, the stator blades were inadequately cooled and they were found to be in poor condition.

Each of the rotor blades was pressure and flow tested individually after the 100 hour test. It was found that of the 45 blades used, seven blades had developed leaks. Almost all the leakage was at the brazed joints and was very small. It was found that there was slight reduction in the individual flow capacity of the blades. There was minor evidence of internal corrosion and a few cases of foreign particles that had either entered the machine during operation, or had been left in the blades in the process of fabrication. In general, however, the condition of the rotor coolant system was extremely good. The coolant pickup at the extreme aft end of the shaft was found to show evidence of cavitation. This unit had been operated for a total of 200 hours and with minor modifications, this problem can be eliminated.

From the operation of the single-stage turbine, it has been concluded that the application of closed-system liquid-cooling at the rotor of a gas-turbine engine is entirely feasible and can result in practical configurations that can yield acceptable performance.

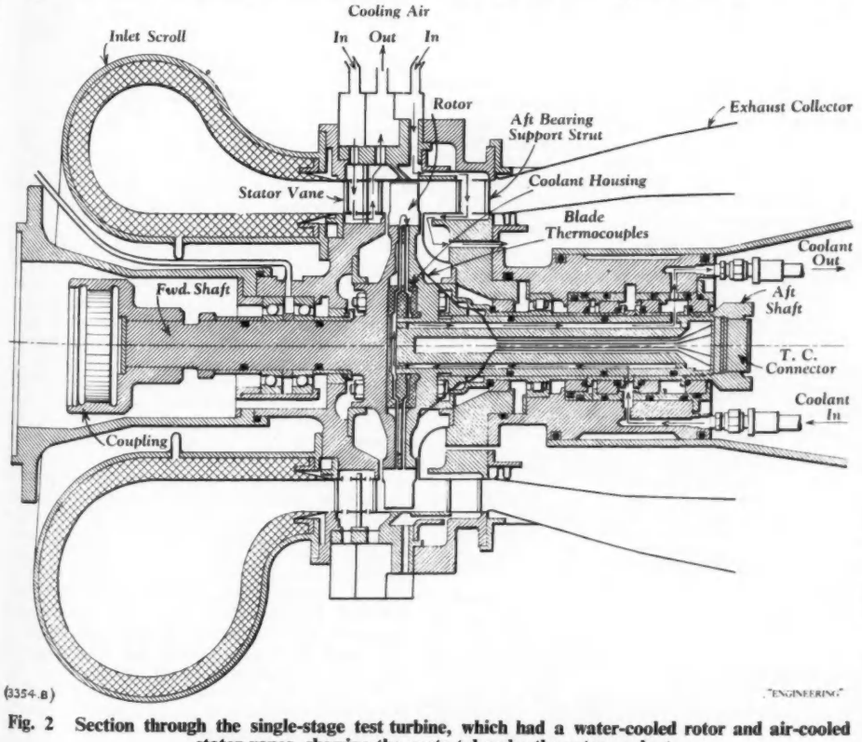

Fig. 2 Section through the single-stage test turbine, which had a water-cooled rotor and air-cooled stator vanes, showing the route taken by the rotor coolant.

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DESIGNING FOR THERMAL STRESS

A lecture, of interest to all concerned with mechanical and thermal stress design problems associated with pressure vessels, will be delivered by Dr. G. Horvay at Hopkinson Building, The University, Manchester, on Tuesday, August 14, commencing at 2.30 p.m., when it is hoped that time will be available for some discussion on relevant topics. Dr. Horvay, who is at present attached to the research department (metallurgy and ceramics) of the General Electric Company, Schenectady, New York, was previously an official of the Knolls Atomic Power Laboratory, operated by the same firm. In that capacity he was responsible for many publications dealing with problems of mechanical analysis in reactor technology. Persons wishing to attend the lecture are asked to notify Professor J. Diamond or Mr. J. P. Duncan, at Manchester University, of their intention.

EQUAL-LOUDNESS CONTOURS FOR PURE TONES

A NEW INVESTIGATION

The intensity of a sound wave, defined as the average rate of flow of energy across unit area of the wave front, can be measured without the intervention of the ear. It is usually expressed in terms of the associated pressure amplitude, the intensity of a plane or spherical wave in an unbounded medium being proportional to the square of its pressure amplitude. When the ear is substituted in place of the measuring instrument (which may be a calibrated microphone) it will, if the wave is of sufficient intensity and if its frequency lies between certain limits, hear a sound to which a definite loudness can be attributed. This loudness depends primarily upon the sound pressure of the stimulus, but it also depends upon the frequency and wave form. Experience shows that there is a sufficiently direct correspondence between the physical magnitude of the stimulus presented to the ear and the sensation of loudness experienced by the listener to provide a firm basis for correlating loudness with intensity.

In practice, relative intensities are of greater significance than absolute values. The sound pressure level of a sound wave is customarily specified by taking, as the term of comparison, an effective pressure P_0 equal to 2×10^{-4} dyne per sq. cm. (corresponding very nearly to the threshold of audibility for a pure tone of 1,000 c.p.s.). If the effective pressure in the sound wave is P dynes per sq. cm., its sound pressure level will be given, in decibels referred to a base of 2×10^{-4} dyne per sq. cm.), by

$$10 \log_{10} \left(\frac{P}{P_0}\right)^2, \text{ or } 20 \log_{10} \frac{10^4 P}{2}.$$

Such a logarithmic scale is very convenient because the very large factor of 10^7, which represents the ratio of the pressure amplitude of the loudest tolerable to that of the feeblest audible sound, is thereby translated into the more manageable figure of 140 dB, and also because the response of the human ear to sound broadly follows the Weber-Fechner law. By definition the loudness level of a sound, in phons, is numerically equal to the sound pressure level of a simple tone of frequency 1,000 c.p.s. which is judged by a listener of normal hearing to be equivalent in loudness. On this basis a family of equal-loudness contours, showing the related values of sound-pressure-level and frequency required to produce a given loudness level for a normal listener can, be obtained. Such curves are of basic importance in many aspects of communication engineering, such as in computing the loudness levels of complex sounds from objectively measured spectrum analyses and in designing frequency weighting networks for objective noise meters, radio receivers and record reproducers.

Previous investigations of equal-loudness relations under free-field conditions of listening were carried out by Fletcher and Munson in 1933, and by Churcher and King in 1937 but, over parts of the auditory sensation area, the discrepancies between them precluded the possibility of deriving an acceptable standard set of contours from them. The present investigation* was undertaken by Mr. D. W. Robinson and Mr. R. S. Dadson at the National Physical Laboratory to obtain a new and more comprehensive set of data based on a mature consideration of all the issues involved. In the course of the experimental work, extending over nearly four years, many more subjects were tested than hitherto, and several new techniques were introduced in order to cover the widest possible range of intensity and frequency. For completeness the equal-loudness relations must be associated with a threshold curve appropriate to the same conditions of listening, as this forms a natural " zero " for the whole set of curves. The investigation accordingly included a re-determination of the threshold of audibility.

EXPERIMENTAL PROCEDURE

Observers with normal hearing, as verified by otological examination, were selected from the personnel of the laboratory. A team of 90 persons, 45 of each sex, with ages ranging from 16 to 63 years participated in about 30 tests. In addition a second team, consisting of 17 men and 13 women of average age about 30 years and all distinct from members of the larger group, took part in over 100 tests, with results barely distinguishable from those of the larger group.

The sounds were presented to the individual listeners in the form of free progressive plane waves of sinusoidal form, with the observer listening binaurally and directly facing the oncoming wave. Except for the highest frequencies, the tests ranged from threshold to sound pressure levels of 130 dB (bordering on the threshold of discomfort) and in frequency from 25 to 15,000 c.p.s. Except for the lowest frequencies the subjects were seated on the axis of, and directly facing, various sound sources in a lagged (anechoic) room, a headrest or sighting wires being provided to fix the head position. Measurements of the ambient noise level in the test room showed it to be lower than the normal threshold of hearing.

A large part of the investigation was carried out with conventional cone-type loudspeakers supplemented, in the high intensity level range, by the use of a powerful reflex horn loudspeaker. For the higher frequencies a plane array of 28 2½ in. cone speakers, matched in sensitivity and equalised in phase, was used in conjunction with the reflex horn, the latter supplying the 1,000 c.p.s. tone. For some work at 15,000 c.p.s. at high intensities, a resonant barium titanate transducer, in the form of a cylinder of diameter 4·7 cm., was employed.

To overcome the difficulty of securing the high intensities required at the lowest frequencies with direct radiators in an anechoic room, a special form of duct, designed for low frequency microphone calibration, was used, the driving unit employed being an 18 in. cone loudspeaker with a modified coil assembly. The question of harmonic distortion and circuit noise at high intensity levels was carefuly studied.

* "A Re-determination of the Equal-loudness Relations for Pure Tones," by D. W. Robinson and R. S. Dadson. *British Journal of Applied Physics*, vol. 7, No. 5, May 1956, pages 166–181.

Attenuation (dB) 6 8 10 12 14 16 18 20 22 24 26 28 30
AOBOAOB
BOAOBOA
(a)
Attenuation (dB) 8 10 12 14 16 18 20 22 24 26 28 30 32
AOBOAOB
BOAOBOA
(b)
(3673.A.)

Fig. 1 Typical records from equal-loudness test using the constant-stimulus method.

1 signifies first tone heard was louder; i.e. tone A in upper rows, tone B in lower.
2 signifies second tone heard was louder.

"ENGINEERING"

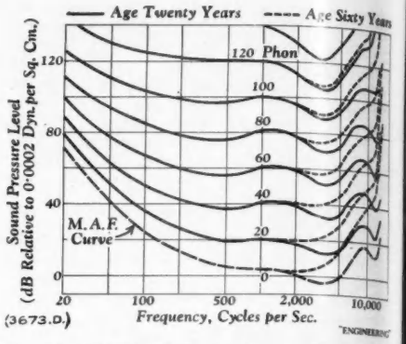


Fig. 2 Equal-loudness contours showing age variations.

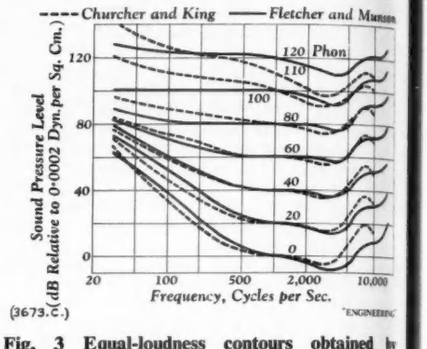


Fig. 3 Equal-loudness contours obtained by earlier investigators.

Most of the equal-loudness tests were carried out using the constant stimulus (CS) method in which the listener is called upon simply to make judgments of loudness inequality but is otherwise passive. For the most part comparisons were made between a pure tone of constant intensity and frequency, and a pure tone of 1,000 c.p.s. at intensity levels which were varied at random. A number of comparisons between tones other than 1,000 c.p.s. was also made, in part to demonstrate the invariance of the equal-loudness relations, but also in cases where instrumental limitations precluded reproduction of the 1,000 c.p.s. tone under the reference conditions. The time sequence patterns A O B O A O B and B O A O B O A were employed, where A represents the fixed stimulus, B the randomised variable stimulus and O a period of silence. The order of presentation of these sequences was randomised as well as the level of B. The growth and decay of the tones were retarded by an electronic switch in order to eliminate the disturbing click heard with rapid transients. The switching was complete in 0·15 sec. and the durations of A, B and O were sufficient to ensure the attainment of full sensation (1 to 3 sec.).

Equal-loudness comparisons were not normally taken below 20 phons, since tests at lower levels are unreliable due to dispersion of the threshold values and consequent failure for some fraction of the observers.

A modification of the normal CS procedure enabled the practical limit of intensity set by the apparatus to be extended and results of comparable reliability to be secured in a shorter time.

The result of each equal-loudness test was obtained by the operator in the form of a chart showing the judgment recorded at each intensity level of the variable tone. These levels were presented at random and recorded in the form shown in Fig. 1. In Fig. 1 (*a*) the pattern is symmetrical and the transition value clearly corresponds to the attenuation setting, 16·5. For the unsymmetrical pattern of Fig. 1(*b*) the mid points of the ranges of uncertainty in the upper and lower rows of judgments were

averaged to give, in this case, a transition value of 17. Having arrived at these values the next step is to deduce from them the normal equal-loudness relations for the group. In the majority of the tests the results conformed fairly closely to the normal error law, provided the levels of attenuation were expressed in logarithmic units. The results adopted for incorporation in the tables and curves of equal-loudness were, in general, the modal values for the group of observations concerned. When the mode was ill defined, as in tests at the higher frequencies, where the necessary separation into age groups resulted in smaller numbers of observations per group, the mean value was adopted.

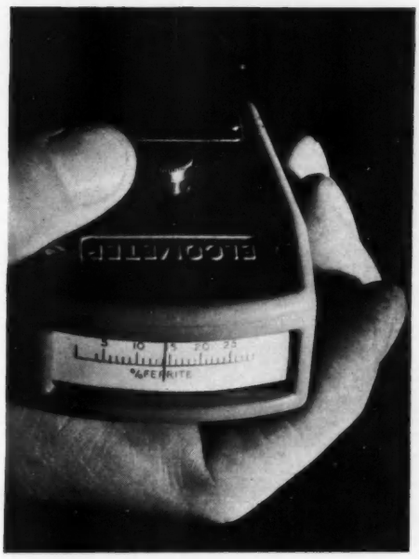
The method adopted for the determination of the minimum audible field was to switch the tone on and off at irregular intervals of a few seconds starting from a clearly audible level and decreasing by 2 dB steps until the observer no longer signalled in synchronism, then increasing by the same amounts until the observer again responded, and subsequently repeating the whole procedure at levels staggered 1 dB with respect to the first set. Though determined in a substantially different way, the threshold values were entirely consistent with the equal-loudness data and, in fact, the zero loudness contour could have been predicted from them with considerable accuracy.

RESULTS

The full experimental results are tabulated in an appendix to the origin paper. The relations connecting sound pressure level in dB with equivalent loudness in phons were found to be expressible by formulae, quadratic in sound pressure level, involving parameters that are functions of the frequency, the sensation level of the tone and the age of the observer. The final conclusions can, however, be more compactly summarised in the family of curves shown in Fig. 2 which includes the minimum audible field curve as well as the equal-loudness contours at 20 phon intervals from 20 to 120 phons. Bearing in mind the number of persons tested the accuracy of the smoothed equal-loudness relations is estimated to be within $\pm$ 1 phon over the major part of the auditory diagram. Above 1,000 c.p.s. it was necessary to divide the observers into age groups. The separation between the age groups becomes dominant at 15,000 c.p.s., is greatest at the threshold level and progressively decreases as the intensity is raised. For clarity only the curves for 20 and 60 years of age are drawn on Fig. 2. For comparison the equal-loudness contours determined by Fletcher and Munson and by Churcher and King are shown in Fig. 3. The differences are most apparent at the low frequencies, where the new contours are much more regular in form and devoid of the inflexions that appear on the Fletcher-Munson contours. Another interesting new feature is the dip in the contours in the region 400-500 c.p.s. which is most pronounced for moderate levels of the intensity. There are also differences in detail over the upper part of the frequency range, where the results are influenced by diffraction effects. Whereas Fletcher and Munson show the loudness level increasing with the intensity level at an increasing rate above 6,000 c.p.s., the present results indicate an opposite tendency.

The principal difference as regards the threshold levels consists in a lowering of the threshold of the order of 10 dB at the low frequency end combined with a rise of 4 dB at 1,000 c.p.s. (the minimum audible field at this frequency being 4·2 dB re 2×10^{-4} dyne per sq. cm.). Comparisons at higher frequencies are not possible in the absence of information about the ages of the observers in the two previous investigations.

This important research of Robinson and Dadson will make a substantial contribution towards securing agreement on a standard set of equal-loudness contours. An extension of the work to include equal-loudness relations for sound distributed in particular frequency bands is in progress.



The Elcometer is designed for the speedy determination of the quantity of ferrite present in welds, rods and fabricated austenitic-steel components.

RAPID DETERMINATION OF FERRITE IN AUSTENITIC WELDS

The quantity of ferrite present in austenitic-steel weld metals has an important bearing on the soundness of welded joints as, if the percentage is too great, the metal may become embrittled as a result of the formation of the sigma phase which is generally considered to be a hard and brittle intermetallic chromium-iron compound.

Recently a rapid method of checking the ferrite contents of welds and of rods, sheets and fabricated austenitic-steel components has been developed. It consists of a modification of a device manufactured by the East Lancashire Chemical Company, Limited, Fairfield, Manchester. This device, known as the Elcometer, was originally developed for measuring the thickness of non-magnetic layers, such as paint and plastic coatings, on magnetic surfaces.

The Elcometer, which is shown in the accompanying illustration, is a pocket-sized instrument operating on the principle that an increase of the magnetic-flux intensity between the two soft-iron test probes of a U-shaped magnetic circuit reduces the forces on a spring-loaded magnetic needle in a parallel magnetic branch. For the measurement of the (magnetic) ferrite content in a (non-magnetic) austenitic metal, the tension of the spring is adjusted so that the needle on the scale gives a reading corresponding to the ferrite content of a reference sample.

It is claimed that while the readings furnished are not as strictly accurate as those obtained by lengthy laboratory tests, hitherto the only alternative, they are sufficiently correct to be of immediate practical value to the welding engineer or store-keeper.

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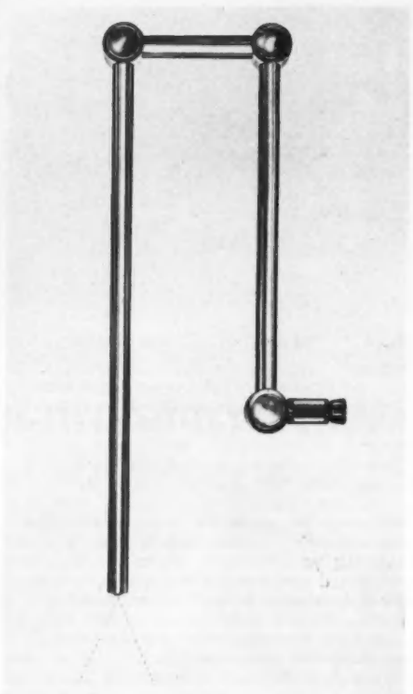
INDUSTRIAL PERISCOPES

Scanning Prisms Fitted

There are many occasions in modern industry when it is required to observe an object while maintaining a protective screen in between the object and the observer. There are other occasions when it is not possible from a certain position to see directly a gauge or dial. Among the methods devised for overcoming these difficulties are a series of periscopes made by J. Bodson et Fils and distributed in this country by P. W. Allen and Company, 253 Liverpool-road, London, N.1.

The periscopes consist of a tube, usually 1·2 in. in diameter, with an objective at one end and an eyepiece at the other; the maximum efficient length of this diameter being 23 ft. Prism units are available so that varying shapes can be built up—one for seeing over an intermediate wall is shown in the illustration. With an angle of view limited to 6 deg. magnifications up to



Periscopes up to 23 ft. long can be built up from parts to view objects indirectly; this example is for looking over a protective wall.

eight times are available, but the normal angle of view is approximately 45 deg. with unit magnification. To increase the field of view a scanning prism can be attached to the instrument, which will turn within the objective tube or, alternatively, can be arranged to move to and from the objective. Objective heads can be watertight or airtight and special materials are available for use in radioactive areas. It is claimed that photographs can be taken easily through the instrument and a photographic attachment for the eyepiece is available.

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80 TON ELECTRIC STEEL-MELTING FURNACE

The Iron and Steel Board have given their approval to a scheme formulated by W. Beardmore and Company, Limited, Parkhead, Glasgow, for the reconstruction of their steel-melting shop. The scheme, which will take about five years to complete, involves the replacement of the company's open-hearth furnaces by electric-arc furnaces at an estimated cost of £1,600,000. This will be financed from the company's own resources.

In order to maintain output during reconstruction the work will be carried out in stages, the first of which will be the installation, by the Electric Furnace Company, Limited, Weybridge, Surrey, of an 80 ton electric furnace. When completed it will be the largest of its type operating in this country at the present time. It will have a transformer rating of 18 MVA and will have a productive capacity of at least 70,000 tons of steel per annum.

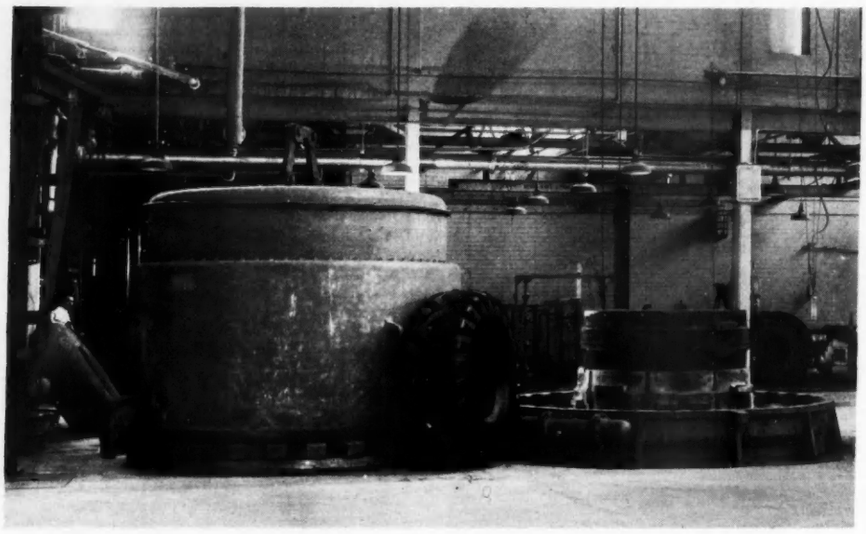

Fig. 1 A finished tyre, 7 ft. in diameter, stands by the moulding barrel which has been lifted clear of the base. Two moulds are standing on the latter.

OFF-THE-ROAD TYRES

By H. Willshaw, O.B.E., M.I.MECH.E., F.I.R.I., A.M.S.A.E.*

The range of pneumatic tyres which industry now demands from the manufacturer is steadily widening year by year. Tyres for high-speed racing and production model cars have to withstand the stresses brought about by still greater speeds; special tyres are called for to operate over snow and ice; aero tyres are required to maintain their properties at extremely low temperatures in the stratosphere; and many other extremes of service provide special problems for the designer. One of these extremes has resulted in the evolution of very large and heavy tyres, for use on comparatively slow-moving but heavily loaded vehicles, such as earthmovers operating away from roads over unmade country. These are usually described as "off-the-road tyres" and the severe conditions under which they have to operate raise many problems in their design.

The production of such very large tyres also presents important problems which have had to be solved. Their nature can be gathered when it is realised that one of the largest tyres of this type has an outside diameter of 88 in. and a width exceeding 33 in., the weight of the outer-cover alone being approximately 2,500 lb.

When such a tyre is vulcanised and moulded, an inflatable air-bag maintains an internal pressure of 350 lb. per sq. in., and steam at up to 80 lb. per sq. in., applied outside the mould, provides the temperature required. The moulds are stacked inside a large barrel-type chamber and to keep the two halves of the moulds together, without movement, a closing force of 970 tons is provided hydraulically through a rubber diaphragm. Individual moulds for such tyres weigh approximately 14 tons.

The solution of the engineering problems involved was facilitated by the availability of war-time equipment, installed for the manufacture of certain very large tyres on bomber aircraft. This equipment was originally installed, at very short notice, to deal with tyres having an outside diameter of about 74 in. and a width of nearly 27 in. The barrel-type chamber enclosing the moulds and into which the steam is admitted was designed with an internal diameter of 88 in., and was suitable for a total load of approximately 500 tons. This load on the moulds was provided through the medium of a rubber diaphragm of 72½ in. outside diameter with a 10¾ in. hole in the centre; when a hydraulic pressure of 300 lb. per sq. in. was applied, this gave the required load of 500 tons.

This war-time equipment has been reconstructed to have an internal diameter of 120 in. with a rubber diaphragm of 100 in. outside diameter, with the same 10¾ in. hole in the centre, giving a total area of 7,200 sq. in. The application of the hydraulic pressure over this area gives a closing load on the moulds of 970 tons. Fig. 1 shows the general arrangement of the plant. It can be seen that the unit consists of a base (on the right) and a liftable barrel-type chamber (on the left). Both have lugs or bayonet-catches which prevent the two parts from separating after they have been brought together and the upper part rotated by hydraulic jacks. Fig. 2 shows the closed position, where the jacks have rotated the barrel so that the bayonet-catches overlap.

The tensile stress in the barrel has been calculated at 1·76 tons per sq. in. and the shear stress on the lugs at 1·3 tons per sq. in. The weight of the barrel is 22 tons and a 30 ton overhead crane is available to lift it on and off the base. This crane also lifts the moulds on and off the base. Very little heavy foundation work has been required, the depth from the floor to the underside of the base being only 36 in. Some idea of scale can be obtained from the man shown operating the hydraulic jacks in Fig. 2, and the moulded earthmover tyre leaning against the barrel in Fig. 1.

This equipment ranks as one of the largest tyre-vulcanising units in the world. The production of these extremes in tyre sizes presents additional problems at various stages in the production process, the solution of which has called for much thought. Their effective solution means that the British tyre industry is well equipped to make the largest tyres which modern industrial conditions call for.

* Chief Engineer, Dunlop Rubber Co. Ltd.

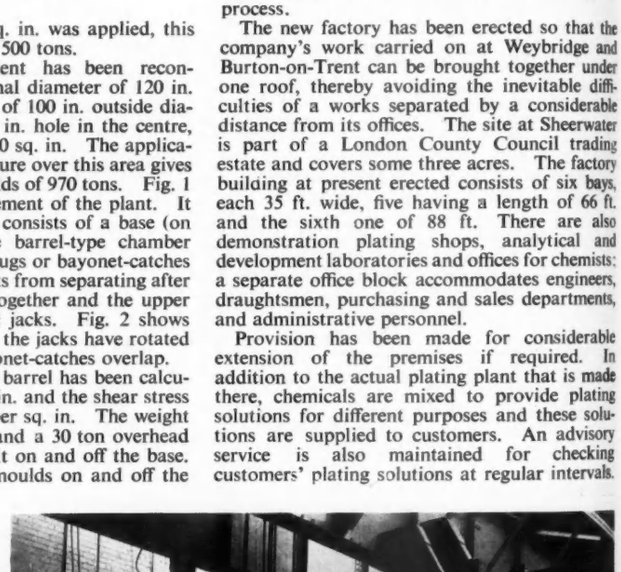

Fig. 2 The bayonet fitting of the mould is locked by hydraulic rams. An unvulcanised cover, prior to moulding, rests on the platform.

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AUTOMATIC PLATING EQUIPMENT

Centralised Factory

Several examples of fully automatic plating machines were on show at the new factory of the Electromagnetic Engineering Company, Limited, at Sheerwater, Surrey, which has just been opened.

Plating and chemical cleaning are processes that lend themselves to automatic operation, since each section of the action is defined by exact timing. The Efco-Udylite machines are based on hydraulic operation, using a reciprocating conveyor system which lifts the parts from the baths after an appropriate time and moves them forward into the next section of the process.

The new factory has been erected so that the company's work carried on at Weybridge and Burton-on-Trent can be brought together under one roof, thereby avoiding the inevitable difficulties of a works separated by a considerable distance from its offices. The site at Sheerwater is part of a London County Council trading estate and covers some three acres. The factory building at present erected consists of six bays, each 35 ft. wide, five having a length of 66 ft. and the sixth one of 88 ft. There are also demonstration plating shops, analytical and development laboratories and offices for chemists; a separate office block accommodates engineers, draughtsmen, purchasing and sales departments, and administrative personnel.

Provision has been made for considerable extension of the premises if required. In addition to the actual plating plant that is made there, chemicals are mixed to provide plating solutions for different purposes and these solutions are supplied to customers. An advisory service is also maintained for checking customers' plating solutions at regular intervals.

Book Reviews

THE UNDEVELOPED FIELDS

Principles of Farm Machinery. By ROY BAINER, R. A. KEPNER and E. L. BARGER. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (8.75 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (70*s*.)

Success in the development of farm machinery depends more on the right attitude of mind than on any other single factor. This is why very many new ideas have started on the farm where, even if the technological engineering background is poor, the attitude of mind is likely to be exemplary. The approach to a problem in agricultural engineering needs to be somewhat similar to that used in Judo, with a careful avoidance of unnecessarily direct action. This is, of course, the countryman's natural approach to life. He is accustomed to making the best use of natural phenomena, by waiting for exactly the right soil or crop condition before taking any action, and when he evolves a new machine he automatically tends to take advantage of any helpful characteristic of the crop concerned, or of the soil.

There is no doubt about the success of this intuitive process, for it has led to the invention of a formidable list of machines and improvements—indeed, the vast bulk of modern equipment is only a short remove from the original farmers' inventions. But the mechanisation of agriculture has now entered a phase where research and development have superseded inventiveness as the most important mode of progress. In their new book Professor Bainer and his colleagues recognise this with an opening chapter defining and describing the functions of research and development. This is a most useful introduction for the student and gives a well-balanced picture of these functions, although the insistence on the vital importance of defining precisely the problem needing solution might appear to suggest that pure research, undertaken simply to study a phenomenon, is not to be countenanced.

In the rest of the book the treatment of the subject is such as to bring to mind, over and over again, the multitude of research problems waiting to be tackled. Discussing crop planting, for example, the authors mention results of recent tests showing how the design of presswheels on drills can affect the emergence of plants and immediately call to mind how little information there is on this point of detail. What makes the book really attractive from this point of view is that a long list of references is given at the end of each chapter. The research problems are implicit in the text rather than explicitly stated, which is no fault. There are places where a more definite comment on the state of the art might not have come amiss—for example, the complexity of adjustment of combine harvesters and the damage they cause is well described, though no opinion is given as to whether these shortcomings may be considered acceptable—but it is easy to see why this was not done (except for a brief general statement, in the first chapter, that progress must be continuous and that many harvesting machines are inefficient or reduce quality). It would have been impossible to know where to draw the line and, anyway, it would have introduced an element of controversy into a book that is essentially factual and descriptive.

This would have been a great pity because the book is well balanced and very readable as it is. The authors have completely avoided both the pitfalls into which they might have fallen. They might have produced a book that was little more than a catalogue of machinery; or, at the other extreme, they might have written something that was little more than an elementary textbook on mechanics, with an agricultural flavour. In fact they have done neither of these; throughout the book the emphasis is on the underlying principles and descriptions of machines and excursions into mechanics are used only to illustrate and examine these principles. Individual chapters deal with different general subjects such as tillage force analysis, crop planting, and hay harvesting. Corn (i.e., maize) and cotton harvesting are given separate chapters. Two of the early chapters deal with cost analysis with respect to design and manufacture and materials of construction. Throughout the book the style is lucid and each subject is dealt with succinctly but comprehensively.

The book is primarily intended for the use of students and cannot fail to be well received for this purpose. It will also be a useful reference volume for designers and others concerned with agricultural machinery. The authors have dealt with the difficulty of nomenclature that always faces anyone writing about agricultural equipment by considering each item individually and calling it by whatever name has seemed to them most appropriate. This may have resulted in one or two anomalies from a British point of view but the authors can hardly be blamed for a state of affairs that can only be put right by international standardisation.

GO OR NOT GO

The Use of Tests in Selection Procedure. Personnel Management Series No. 7. *British Institute of Management*, 8 *Hill-street, London, W.*1. (5*s*.)

The ability to choose staff is rightly considered one of the tests of a good manager, but too often the methods employed are crude and provide little assistance to the instinctive hunch which is the final determining factor. It is, therefore, timely that the British Institute of Management should have published this booklet, prepared by the National Institute of Industrial Psychology, as an introduction and guide to the use of personnel selection tests.

These tests may be one of several types, the most frequently used being tests of mental capacity (" intelligence tests "), tests of special aptitudes (for instance, " mechanical " aptitude), tests of attainment in specific fields, tests which reproduce a particular work task in whole or essential elements of it, and tests designed to explore aspects of personality other than those of ability or knowledge.

Intelligence tests are based on the theory that there exists a general factor of ability, common to all activities, together with specific factors involved in particular operations. This general factor is best measured by means of pencil-and-paper non-verbal tests. While useful tests for special aptitudes exist, the reader is warned that their application calls for specialised advice. A high score in a special perception test, for example, may not itself indicate that a boy will make a good draughtsman, although a very low score might indicate the contrary. In this way the test acts as a " go-or-not-go " gauge. Where attainment tests can properly be used and are well constructed, they offer real advantages over other forms of assessment of the particular attainment under examination. Examples are standards of arithmetic for junior clerical posts or of typing.

By far the most doubtful forms of tests are those designed to answer the question " What *kind* of a person is the candidate ? " Attempts have been made in America to devise " personality inventories," " adjustment scales " and " temperament scales " and they may be helpful, but in this country they are little used and their validity is open to question. For this purpose the interview or methods of group selection which are described here remain necessary. Reference is made to the danger that performances in tests may be improved by coaching, the fear of which has been expressed when they are used in the selection of children for secondary schools; but if proper precautions are taken, as well as care in the choice of tests, this danger can in practice be reduced to a negligible point.

In most areas of selection and promotion, properly selected and used tests can form a useful element of the procedure, but they must be applied with understanding of their limitations and administered by trained personnel. Among batteries of tests successfully devised by the N.I.I.P. is one for the selection of engineering apprentices. All the methods described here are neither more nor less than means of securing evidence about the level and pattern of abilities or about the qualities of disposition of the candidates.

The booklet concludes with a useful reading list and with examples of selection procedures, including group discussions, for the selection of a junior executive, a graduate trainee, a student apprentice and a foreman.

ISOTOPES, DETERGENTS AND OTHER NUISANCES

Principles of Industrial Waste Treatment. By C. FRED GURNHAM. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (9.50 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (76*s*.)

This book is concerned with principles, not with the design and layout of waste-treatment plants. Dr. Gurnham is Professor and Head of the Department of Chemical Engineering at Michigan State University and his book is intended primarily for students. Much has at one time and another been said about the importance of instructing engineering students in the basic principles of their subject in order that they may bring a proper understanding to bear on the problems which they will meet in practice. This is sound doctrine but principles are not likely to be soundly grasped if they are enunciated *in vacuo*; some relation to application is necessary. The point is fully appreciated by Dr. Gurnham. Although he is not concerned with detail design of waste-treatment plants he gives many references to practical applications.

The book is therefore of value to a wider circle than students alone. Many works managers are faced with the problem of dealing with waste and others are called upon to operate existing plants. The author points out that some acquaintance with chemistry and physics is assumed, but users of the book need not be chemists or physicists.

Inherent in the scheme that the book shall concern itself with " principles " there are three chapters on the physical treatment of wastes. They deal respectively with sedimentation, filtration and heat-transfer operations. Sections dealing with the settling velocities of particles, grit removal, oil and grease separation and emulsion breaking deal with their subjects in general terms, but sections are added which review the application of the principles to paper-mill, petroleum, oil and vegetable wastes.

The book covers so much ground that a full account of its contents would be a mere catalogue. Mention may be made, however, of its treatment of two matters which have, in recent years, added to the problems facing those concerned with the treatment and disposal of both industrial and domestic wastes. These are the increasing employment of radio-isotopes and synthetic detergents. Disposal works may have to deal with the former in a dilute form and the way to deal with the long half-life type is concentration by evaporation, ion exchange, incineration or chemical precipitation, the long half-life residue being disposed of by burial in selected isolated sites or packing in drums and sinking in the ocean. Synthetic-detergent foam—an inconvenience and possibly a health menace in many sewage works—may be reduced in quantity by spraying; kerosine is suggested. It is also stated that frothing power may be destroyed by oxidation with chlorine or ozone.

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Units and Systems of Weights and Measures: Their Origin, Development, and Present Status. By LEWIS V. JUDSON. National Bureau of Standards Circular 570. *The Superintendent of Documents, U.S. Government Printing Office, Washington*, 25, *D.C., U.S.A.* (25 cents.)

There are two main systems of weights and measures in use to-day, British (which, with some variations, is also used in the U.S.A.), and Metric. This brochure deals with the history and present status of both systems, and it is not concerned with any of the numerous other systems of minor, and decreasing, importance which are still used in other parts of the world. The work of the American National Bureau of Standards in calibrating and certifying standards of weight and measurement is described. There are comprehensive tables of equivalents of Metric and British units, alphabetically arranged.

Atmospheric Pollution: Its Origins and Prevention. By A. R. MEETHAM. *Pergamon Press, Limited*, 4 and 5 *Fitzroy-square, London, W.*1. (63*s.*)

This book is a second and enlarged edition of a work first published in 1952. It constitutes a comprehensive technical account of air pollution in England, which is stated to be the "smokiest country on earth," and discusses methods of smoke abatement and for the prevention of pollution.

Among other new material, this edition contains data on the lessons learned from the London "smog" of December, 1952, a review of the progress made against smoke and sulphur dioxide pollution, notes on the fumes from petrol and fuel oil, and an account of atomic energy as it is likely to affect the atmosphere.

Chromium-Nickel Austenitic Steels. By F. H. KEATING. *Butterworths Scientific Publications* (in association with Imperial Chemical Industries, Limited), 88 *Kingsway, London, W.C.*2. (25*s.*)

This work constitutes one of a series of handbooks issued by Imperial Chemical Industries Ltd. on a variety of technical subjects. It is primarily intended to be of service to the user of the austenitic stainless steels and is based on the experience of the company in this field. Essentially, it is a reference book for the practical man rather than a treatise for the specialist, but it will also be of use to the metallurgist and, particularly, the beginner and the student.

The Running and Gating of Sand Castings: A Review of the Literature. By R. W. RUDDLE. Institute of Metals Monograph and Report Series No. 19. *The Institute of Metals*, 4 *Grosvenor-gardens, London, S.W.*1. (25*s.*)

The author has been head of the melting and casting section of the British Non-Ferrous Metals Research Association since 1947, and his review is addressed to both the research worker and the practical foundryman. The subjects dealt with include the study of the flow of metals, the fluid dynamics of metal flow, flow in horizontal gating systems, gating systems other than the horizontal, the influence of the gating system on the soundness of the casting, and the application of hydrodynamic theory to the flow of metals.

The Properties of Aluminium and its Alloys. A.D.A. Information Bulletin No. 2. Fourth edition. *The Aluminium Development Association*, 33 *Grosvenor-street, London, W.*1. (7*s.* 6*d.*)

The present fourth edition of A.D.A. Information Bulletin No. 2, replaces the third edition, published in December, 1949. It has been increased in size from 56 to 204 pages and contains, as heretofore, tables of the chemical compositions and mechanical properties of all the aluminium alloys in use in industry.

For the first time, lists of British, American, Canadian and of some European proprietary names, under which many compositions are supplied, are included.

Distillation in Practice. Edited by CHARLES H. NIELSEN. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (3 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (24*s.*)

This work consists of a collection of papers presented at a joint meeting of the Philadelphia-Wilmington section of the American Institute of Chemical Engineers, and students and members of the department of chemical engineering of the University of Pennsylvania. The contents cover recent developments in the evolution of distilling techniques, the design of columns, petroleum-fractionation processes, instrumentation, the operation of distillation equipment, and commercial aspects of vacuum distillation.

Manganese Steel. Published for Hadfields, Limited, by *Oliver and Boyd, Tweeddale-court, Edinburgh*, 1. (18*s.*)

An account of the conception and development of the manganese steel invented in 1882 by Sir Robert Hadfield, Bt., F.R.S., is given in this book, which has been produced by the staff of Hadfields, Ltd.

The steel contains essentially approximately 1·2 per cent. of carbon and 12·5 per cent. of manganese, and the book sets forth the results of many years of accumulated knowledge and experience on the manufacture, treatment and application of the material.

Magnesium Fabricating and Casting. Report of the Technical Assistance Mission No. 104. *Organisation for European Economic Co-operation*, 2 *Rue André-Pascal, Paris* 16*e, France*. (400 francs); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (8*s.*)

This report consists of a description of the various methods of melting, sand casting and die-casting, pressure die-casting, extrusion and rolling, and forming and welding of magnesium and its alloys, adopted in 10 metallurgical plants in the United States visited by the Mission.

Detailed information and statistics, and many line drawings and half-tone pictures illustrating processes and techniques are included.

Physical Aspects of Absorptiometric Analysis. A Consideration of the Principles Involved in and Factors Affecting the Performance of the Hilger Photoelectric Absorptiometer. Special Report No. 55. *The Iron and Steel Institute*, 4 *Grosvenor-gardens, London, S.W.*1. (25*s.*; 15*s.* to members.)

The Methods of Analysis Committee of the Metallurgy (General) Division of the British Iron and Steel Research Association have made a detailed study of the principles employed in the Hilger photo-electric absorptiometer and of the factors affecting the instrument's performance, with special reference to its application to the analysis of iron and steel.

The design, range of application and maintenance of the instrument are all described in the present Special Report No. 55, published by the Iron and Steel Institute. The experimental results are also recorded in detail in the Report.

* * *

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Mobile Power Units. DALE ELECTRIC (YORKSHIRE), LTD., Electricity Buildings, Filey, Yorkshire. Trailer mounted, Diesel-driven power units, 50 or 60 cycles, 25 or 30 kVA. Leaflet.

Railway Signal Control Cables. TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. LTD., Telecon Works, Greenwich, London, S.E.10. Multi-core cables for railway colour-light signal and control circuits. Insulation by Telecothene with polyvinyl chloride as outer sheath. Physical characteristics enable them to be installed underground, in conduits, troughing or on posts. Illustrated leaflet.

Valves and Cathode Ray Tubes. FERRANTI, LTD., Hollinwood, Lancashire. Additional data sheets for receiving and industrial valves, as well as cathode ray tubes.

Steel Tubes, Fittings and Bars. TALBOT STEAD TUBE CO. LTD., Green-lane, Wallsall, Staffordshire. Gives details and size ranges of carbon and alloy steel, stainless and heat-resisting tubes, stainless steel tube fittings, and bright steel bars. Examples are also given of the tube manipulation and fabrication which are undertaken by the company. Illustrated brochure.

Press Brakes. BRONX ENGINEERING CO. LTD., Lye, near Stourbridge, Worcs. Provides details of a range of press brakes of fabricated construction, from 20 to 1,000 tons capacity. Tabulated data are provided as a guide to size-selection. Illustrated brochure.

Stainless Steel Tubes and Fittings. TALBOT STEAD TUBE CO. LTD., Green-lane, Walsall, Staffordshire. Catalogue of a variety of stainless steel tubes. General data and examples of uses for stainless tubes of both normal round and specially-shaped cross-section. Illustrated brochure with table of steels normally used, giving typical analyses. This table of steels is also published as a separate folder. Catalogue of stainless steel tube fittings. Details of a large range of fittings, including tees, bends, crosses and couplings, for fixing to the tube by welding or expanding. Three types are available, all giving full-bore flow, and they are all easily dismantled for cleaning. The fittings are designed for use in the food and dairy industries, but are also suitable for brewing and chemical applications. Illustrated brochure.

Crane and Mill Motors. ENGLISH ELECTRIC CO. LTD., Kingsway, London, W.C.2. Details of design and construction of alternating and direct-current motors designed for crane duties. Strengthened windings, minimum rotor currents, heavy insulation and large bearings. Also details of heavy-duty fabricated-frame motors for steel works' auxiliary drives. These comply with American Association of Iron and Steel Engineers' standards. Designed for 220/230 and and 440/460 volts direct current. Tables of performance and dimensions. Illustrated folder and booklet.

Clip-On Volt-Ammeters. FERRANTI LTD., Hollinwood, Lancashire. Clip-on volt-ammeter with five current ranges up to 1,000 amperes alternating current, and two voltage ranges of 0 to 150 volts and 0 to 600 volts, all selected by a thumb-operated switch. Also a high frequency model with five current and two voltage ranges suitable for use on 400 cycle, 2,500 cycle and 20,000 cycle circuits. Illustrated leaflet. List In.17V.

"Heating and Air Treatment." BRIGHTSIDE HEATING AND ENGINEERING CO. LTD., Ecclesfield, G.P.O. Box 118, Sheffield, 1. Five main sections; first gives technical data on heat transfer, flow through pipes and ducts, and moisture content. Remainder give illustrated examples of air conditioning and treatment, and heating in industry, institutions and commercial buildings. The sections are also available separately.

Cable Trunking. CABLEFLOW LTD., 62 Clapham-road, London, S.W.9. Cable trunking incorporating copper bonding link as an integral part of the connecting sleeve. This link is of sufficient thickness to be drilled and tapped to take a terminal for an earth wire. Range of accessories. Illustrated leaflet.

Limit Switch. SMITH'S INDUSTRIAL INSTRUMENTS LTD., North Circular-road, London, N.W.2. Hermetically-sealed limit switch for currents up to 5 amperes alternating current and 2 amperes direct current, at 250 volts in each case. Operating force 5½ lb. Pre-travel 0·007 to 0·02 in. Over-travel 0·25 in.

Precision Instrument Switches and Transfer Unit. CROYDON PRECISION INSTRUMENT CO., 116 Windmill-road, Croydon, Surrey. Switches for use in precision resistance units, strain gauge selection and thermo-couple work. Technical details of design and construction. Also vacuo junction type of alternating/direct-current converter for use with precision-type direct-current potentiometers. Voltage range from 7·5 to 300 volts. Current range from 18 milliamperes to 5 amperes. Illustrated leaflets.

Automatic Argonaut Welding. BRITISH OXYGEN CO. LTD., Cleveland-row, London, S.W.1. Details of automatic head for use with the Argonaut welding system, providing mechanical equipment for the production welding of heavy sections of metals. Designed to handle 600 amperes direct-current continuously, and useable with "hand" wires from 0·035 in. to 3/32 in. in diameter; also with 3/64 in., 1/16 in., 3/32 in. and 1/8 in. in diameter aluminium-alloy and magnesium-alloy wires.

Electric Motors. BROOK MOTORS LTD., Huddersfield. Constructional details of totally enclosed, fan-cooled and drip-proof motors. Built to British standard dimensions. Leaflet, illustrated in colours.

Electromagnetic Clutches. IGRANIC ELECTRIC CO. LTD., Bedford. Technical details, and methods of construction and operation of Igranic-Stromag electromagnetic clutches. Illustrated brochure.

Powder Reflectometer. EVANS ELECTROSELENIUM LTD., Harlow, Essex. "Eel" power electrometer for determining the specific surfaces of powders of sizes less than one micron by the "testing strength" methods. The photocell and optical system are mounted on a common frame, to which a slide carrying two thimbles for the powder under investigation is fitted. Illustrated leaflet.

Cable Eccentricity Gauge. ADDISON ELECTRIC CO. LTD., 10 Bosworth-road, London, W.10. Direct-reading gauges for controlling the concentricity of insulating coatings extruded over conductors, multi-core cables and metallic sheaths during manufacture. Sensitivity 0·5 per cent. of the wall thickness. Cables up to 3·5 in. overall diameter can be tested continuously during production. Illustrated leaflet.

Lopulco mill with air classifying equipment.

PULVERISING MATERIALS

TEST PLANT FOR GRINDING, SCREENING AND FILTERING

A wide range of machines for grinding, screening and filtering is produced by International Combustion, Limited, 19 Woburn-place, London, W.C.1, and in order to provide the necessary facilities for studying the behaviour of any materials which are required to undergo any or all of these processes, the company maintain a comprehensive test house at their Derby works. In this test house it is possible to conduct test runs with samples of material on any of the machines the company manufacture, as the complete range is installed in full working order, each unit being the smallest commercial size available. Every item of plant is self-contained, and is provided with the necessary ancillary equipment to enable it to be run under normal working conditions.

The test plant is arranged in two sections, both under the same roof, for wet and dry processing respectively, and the machinery comprises a range of pulverising mills of various types, including the well-known Hardinge ball, pebble and rod mills, roller mills and beater-type machines; air classifying equipment; vacuum filtration plant; continuous centrifuges; a hydraulic classifier and thickener; pumps for handling solids in suspension in liquids; vibratory screens of the electrical and mechanical type; and vibratory feeders. There is also a section of the test house devoted to research into heat transfer and certain other features of boiler flue gases.

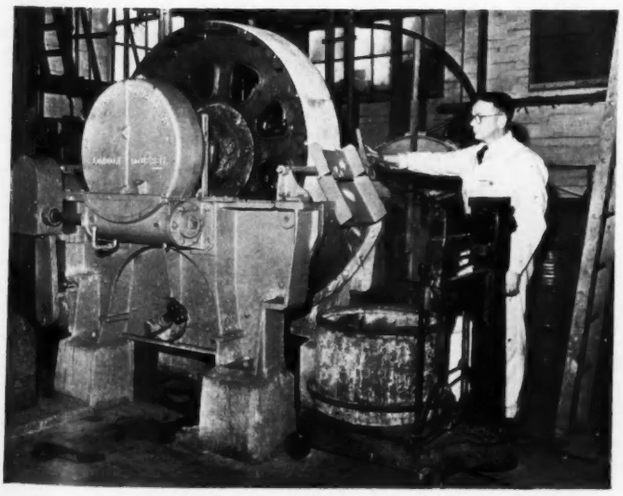
The grinding equipment is arranged for air classification of products, except one machine, a Hardinge wet ball mill, which works in conjunction with a rake classifier. The dry mills all operate with an air circuit which is kept at a pressure slightly lower than that of the atmosphere, and there is thus no danger of any of the fine particles escaping from the plant, a vital consideration when dealing with materials which are toxic or otherwise injurious to health.

When the materials are ground in the wet state the classification is effected hydraulically, and it is necessary to provide means for separating the water from the classifier products. A 4 ft. 6 in. diameter thickener is installed for this purpose, together with several rotary vacuum filters; these latter include a 10 sq. ft. cell, a 10 sq. ft. end flow, and a 3 ft. 6 in. disc filter. Various types of filtration are thus catered for, but there are certain materials which cannot be filtered successfully, and there are cases where means other than filtration might be more successful. Other equipment provided for the removal of suspended solids from liquids includes a recently introduced machine, the Dynocone.

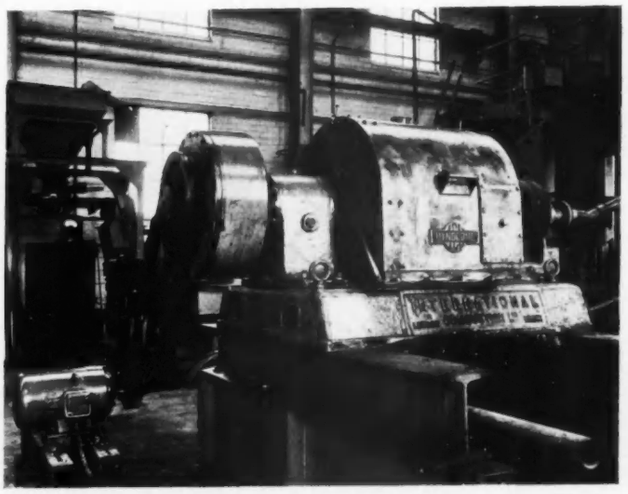
CONTINUOUS CENTRIFUGE

The I.C.L. Dynocone continuous centrifuge operates on a principle which was developed some years ago, but which encountered difficulties in the method of driving. The Dynocone employs a new means of driving, which has overcome the earlier difficulties and has proved entirely successful. In its essentials the machine consists of a shell or bowl in the shape of a frustrum of a cone, revolving on a horizontal axis, in which a tapered screw conveyor revolves in the same direction, but at a slightly higher speed. The fluid feed is admitted to the bowl through the centre tube of the revolving conveyor, and the liquid and solid constituents receive an angular momentum which imposes a high centrifugal force on the suspended solids. This causes the solids to settle on the bowl surface, while the liquid becomes a solid of revolution, the surface of which is cylindrical. When the liquid reaches a pre-determined level it overflows through discharge ports at the large end of the bowl; meanwhile, the solids which have settled are conveyed out of the liquid to the small end of the bowl and there discharged, being progressively de-watered on the way by centrifugal force.

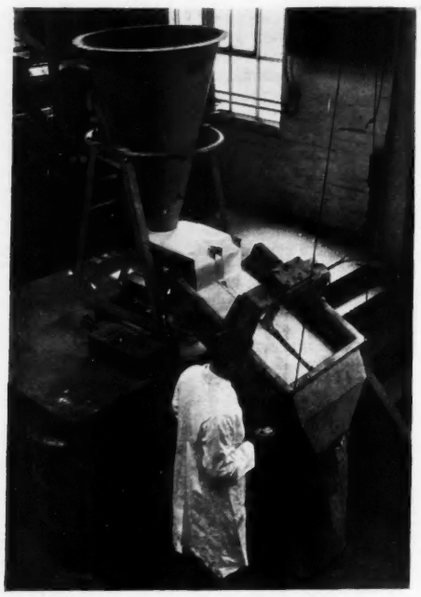
The drive, which at first sight appears simple, presented a considerable problem in the beginning, and it is in this respect that the Dynocone is novel. Because of the very high frictional forces between the solids and the bowl surface, caused by the centrifugal action, the torque required to revolve the screw to remove the solids is very high, although due to the relative speeds of the conveyor and bowl, the actual power required is small. In earlier machines the screw and bowl were geared together to give the required speed differential, and driven by a common motor. If an overload occurred costly gear replacements could result, since the screw and bowl were



Test in progress on end-flow rotary filter. Other filters in the test house include both cell and disc types as well as a vacuum plant.



Dynocone continuous centrifuge. The control motor is on the left, the main drive on the right.



Hummer electric vibratory screen under test with material fed by Syntron feeder.

geared together and it was impossible, owing to the rotational energy of the unit, to remove the overload immediately by tripping the motor.

In the Dynocone the bowl is driven by the main motor, and the screw conveyor is carried on the output shaft of a planetary gear train which revolves with the bowl. The input shaft of the gear train is coupled to a small "conveyor control motor," and the relative rotations of screw and bowl are obtained by arranging a speed difference between the gear input shaft and the machine. In operation, with the machine on load, the resistance between the screw and the bowl caused by the removal of solids produces a generated current in the control motor, which increases as the machine is loaded further. By this means the relatively high torque needed to screw out the solids against centrifugal force is indicated clearly, and when it approaches a value dangerous to the gearing, the motor is tripped out by the usual current overload device.

Many different materials have been handled successfully by Dynocones; currently, one machine in the test house is dealing with the continuous separation of ammonium sulphate from liquor, a purpose for which several machines have already been sold.

MATERIAL MOVEMENT

Liquids, solids, and solids in suspension in liquids in various concentrations have to be handled to and from the different machines installed in the test plant, and equipment of the company's manufacture is available in the plant for test and experiment with sample materials. For handling solids suspended in water, such as mining pulps and sands, ash from hydraulic sluicing plants, or pottery slips, the Vacseal pump has been available for some time. By virtue of its design the pump gland is always under a slight suction when the pump is at work; no sealing water is needed and the pump is, in effect, virtually glandless. It is made in metal suitable for the work to be done, or with all the parts in contact with the material being pumped encased in a suitable type and grade of rubber. Vacseal pumps are installed in circuit with some of the machines in the test house, and they can be put into operation with any material which it is desired to test.

Investigations of the feeding of solids can be carried out by the range of Syntron electric vibratory feeders installed for feeding and conveying materials in conjunction with or independent of, a range of screens. The feeders are equipped with their normal rheostatic control, which gives infinitely-variable adjustment of feed over the whole range of output of the machine. Syntron equipment operating on the same principle is also installed for feeding small components such as screws, bolts, bottle caps and fuses for further processing; these machines can be designed for oriented-position feeding, and have the same rheostatic control as the bulk material feeders. The screens which are installed in the same part of the test house as the feeders are of the Hummer electric type or the Ty-Rock mechanical pattern, and with them it is possible to carry out different types of screening tests, with two or more screened products according to the number of decks used.

The test house operates in conjunction with the Company's chemical and physical laboratory, and a complete examination of the behaviour of a particular material in various types of grinding, screening or filtering units can be combined with investigations into such matters as particle size, settling rate and filterability. A samples room adjoining the test house contains several thousand specimens of materials which have been tested, the data obtained having been filed for future reference. It is often possible, on the basis of past experience and with the filed data as a guide, to make recommendations for suitable types of equipment for a specified performance and output, but if there is any doubt, or if the material is one which has not been dealt with before, the facilities of the test house for full-scale test runs can be brought into use at any time.

ZIRCONIUM-ALLOY INGOT PRODUCTION

A consumable-electrode arc-melting process perfected at the North-West Electrodevelopment Experiment Station of the United States Bureau of Mines, at Albany, Oregon, has made possible the casting, on a production basis, of homogeneous zirconium-alloy ingots meeting the exacting specifications laid down by constructors of atomic reactors.

Particulars of the process are given by Mr. R. A. Beall, Mr. F. Caputo and Mr. E. T. Hayes in a report of investigations (No. 5200) published by the Bureau.

Zirconium rapidly absorbs harmful impurities from the air when molten and, for this reason, it is melted in an electric-arc furnace at low pressures and under a blanket of inert gas comprising $\frac{1}{2}$ of argon and $\frac{1}{2}$ of helium. The consumable zirconium electrodes consist of square-section pressed sponge-metal bars measuring 2 in. by 2 in., by 20 in. in length, and these are end-welded within the arc-melting furnace to form a continuous 2 in. square electrode. Water-cooled copper cups, having diameters of 6 in., 7 in., 8 in., or 10 in., are used as moulds. A typical melt requires a direct current of 3,700 amperes at 45 volts which gives a melting rate of 4 lb. a minute. When the copper cup is filled to a reasonable height the power is first lowered, to reduce the depth of the molten pool and the consequent depth of the shrinkage cavity, and is then switched off. After a 30 minute cooling period the ingot has shrunk away from the wall of the cup and may be removed by inverting the cup. In continuous operation it is stated that three men can produce from 4 to 5 ingots in a shift of eight hours. Many ingots, each 6 to 10 in. in diameter and weighing 300 to 500 lb. have been produced at the Albany station. Magnetic stirring and double melting have been found to improve the homogeneity of the metal.

The most interesting feature of the Bureau's process, however, is the method finally adopted for adding the alloying elements to the melt, it being stated that: "characteristically, the arc-melting process is conducive to segregation." To overcome this the "compressed-pill" technique is employed. The pills, $\frac{3}{8}$ in. in diameter by $\frac{1}{4}$ in. thickness, are compacted in a high-speed commercial, tablet-making machine from blended tin, iron, chromium and nickel powders. A pill counter, geared to the electrode feed motor, serves as a means of adding the alloying elements at a rate proportional to the melting rate of the electrode. The use of the pills has resulted in the production of ingots more homogeneous than any made by any other method investigated. This method, in conjunction with magnetic stirring and double melting, has yielded zirconium alloy ingots meeting the rigid specifications referred to above.

In proof of this the report contains a table, reproduced as Table I below, indicating that the reproducibility, within the tolerances set, for each alloy constituent has been maintained. In the case of each element the number of samples analysed was 30. Zircaloy 2 is a quaternary alloy containing 1·5 per cent. of tin, 0·12 per cent. of iron, 0·05 per cent. of nickel and 0·10 per cent. of chromium. Brinell-hardness tests were carried out on 11 specimens and the range was found to be 178–181 numbers and the average, 179.

TABLE I *Analysis of Zircaloy 2 Ingot*

Analyses	Tin	Iron	Nickel	Chromium	Nitrogen
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Average ..	1·52	0·13	0·051	0·097	0·001
Range of 30 samples ..	1·47 —1·64	0·11 —0·15	0·05 —0·06	0·08 —0·10	>0·001 —0·002

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WALL CHART

A new version of the Movigraph wall chart has been produced by Adapta-Charts Limited, 129 Hammersmith-road, London, W.14. As in the earlier models the base consists of a plastics panel, measuring 23 in. by 11½ in. in the smallest size, having 2,000 perforations to the square foot. Several panels can be butted together to form an installation of the required size. There are six major signals, each in 12 colours, giving over 20,000 signalling combinations; figures and letters are also available. The flow lines consist of a coloured elastic cord which is pulled across the chart and kept in position by a peg. They return to the starting position when not in use.

Also available are card index panels containing either 80 6 in. by 4 in. cards or 50 8 in. by 5 in. cards. Alternatively an index holder can be inserted at any position on the panel, each holder being capable of carrying 11 index strips.

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FLAME CLEANING A STEEL TANK

Constituting a prominent landmark at Dunstable, Bedfordshire, is an elevated water tank known as the Horton ellipsoidal tank, constructed for the new Bedford motor-vehicle plant of Vauxhall Motors, Limited, by the Motherwell Bridge and Engineering Company, Limited. The tank holds 500,000 gallons of water and the top of the tank is 135 ft. above the ground. Its purpose is to give a constant pressure of water in the factory. The tank is made of all-welded steel plates; it is 56 ft. in diameter and 44 ft. deep and is supported on eight steel tubular legs and a six-foot diameter centre column. The whole structure weighs 200 tons.

During the construction the tank was flame-cleaned, both internally and externally, by means of the C.H. and F.H. type descaling equipment of the British Oxygen Company, Limited, using both 4 in. and 6 in. nozzles. This process removes rust and scale and offers a clean, warm steel surface for the application of paints and other finishing media.

In the Dunstable operation 16,200 cub. ft. of oxygen and 18,000 cub. ft. of dissolved acetylene were consumed. Four men were employed on the work of flame-cleaning which took two weeks to complete.

JOINTING ALUMINIUM CABLES

HIGH-TEMPERATURE NON-ORGANIC FLUX

The increasing use of aluminium for electrical conductors, although it leads to economies, has been retarded by difficulties in jointing. It has, in fact, been found necessary to pre-tin the conductors before fitting the lugs or ferrules and to step back their ends and splay out the inner wires before soldering. It has also been necessary to control the temperature of the solder so as not to overheat the flux, while other drawbacks are the poor penetration of the metal into the interstices between the strands and the objectionable smell from the fumes. These shortcomings of organic flux have, however, had to be accepted owing to the insistence by some users that the soldering temperature should not exceed that necessary for copper—about 250 deg. C. Nevertheless, higher soldering temperatures have been used on the Continent with the result that improved " wetting " of the strand by the solder has been obtained and the area of penetration has been increased.

Johnson and Phillips, Limited, Charlton, London S.E.7, have now developed a new solder flux—Junal 5—which they claim overcomes the disadvantages mentioned. It is supplied in paste form and can be used for making joints into ferrules and end terminations by a process almost identical with that employed with copper conductors. A basic requirement is that it must be heated to 350 deg. C. for a few seconds before being used. Unlike organic fluxes, however, it is not harmed or rendered inactive by overheating; in fact its action improves as the temperature is increased.

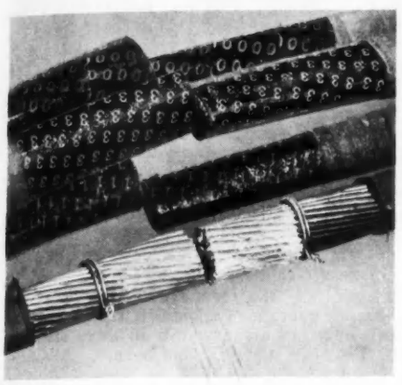

Fig. 1 Butt-ends of aluminium conductors lightly smeared with Junal 5 prior to the application of the ferrule. The conductors must not touch.

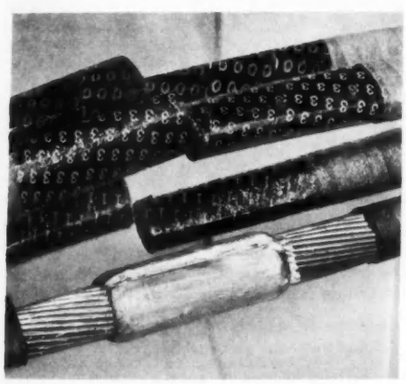

Fig. 2 Ferrule in position.

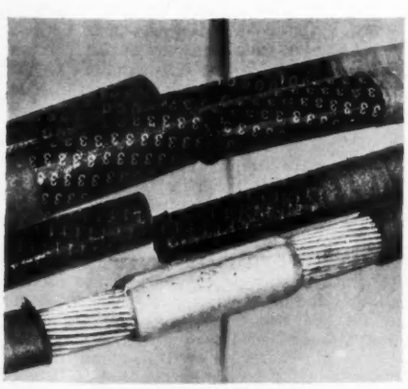

Fig. 3 Complete joint filled and wiped in the normal manner.

SOLDERING PROCEDURE

The procedure followed in making use of Junal 5 is, after trimming back the insulation, to butt the squared off ends of the conductors leaving a $\frac{1}{4}$ in. gap between them, as shown in Fig. 1. This gap is important as the conductors must not touch. The conductors are then lightly smeared with Junal 5 for the length of the ferrule. This ferrule is of the weak-back type and after it has been applied and tightened a little flux is smeared along its slot and in the gap between the conductors, as illustrated in Fig. 2.

The next step is to pour solder, which has been heated to at least 400 deg. C., on to the sides of the ferrule until the flux is fully molten and frothing. On conductors of 0·4 sq. in. cross section this usually requires two applications of the solder. The solder should not if possible, be allowed to enter the ferrule at this stage. The solder at a temperature of 400 deg. C. or more is then ladled over and into the joint to heat it as quickly as possible, the operation being repeated four or five times until copious white fumes are given off. Finally the ferrule can be tightened further if necessary and the joint filled and completed in the normal manner. A view of a completed joint is given in Fig. 3.

End sockets and other terminations can be treated in a similar manner to copper conductors, the strand being smeared with flux particularly on the butt end. The socket is then heated to melt the flux after the solder is ladled over it until again white fumes are given off. Finally, the joint is completed in the conventional manner.

It is pointed out that the aluminium should not be tinned before it is placed in the socket or ferrule because the full advantages of the flux are only obtained when it is heated in a semi-confined space. In fact, when heated on freely exposed aluminium surfaces full reduction is not always obtained and a crust of oxide may form. On the other hand, a light smear of Junal 5 on copper or brass fittings readily tins them when they are heated.

As a temperature of 350 deg. is required to tin the strand there is a risk that the insulation may become charred. In practice, however, it is found that any charring that may occur is confined to the innermost paper and only extends to some $1\frac{1}{2}$ in. from the end of the ferrule. It can therefore be avoided by trimming the insulation back for a greater distance.

Comparative tests have already shown that joints made with Junal 5 are more solidly filled and are at least equal to those made with organic fluxes in conductivity and mechanical strength. In short term tests under damp conditions they are more reliable than those made with organic fluxes, although like all soft soldered joints on aluminium they should be protected against moisture. Fig. 4 is a sectional view of a joint.

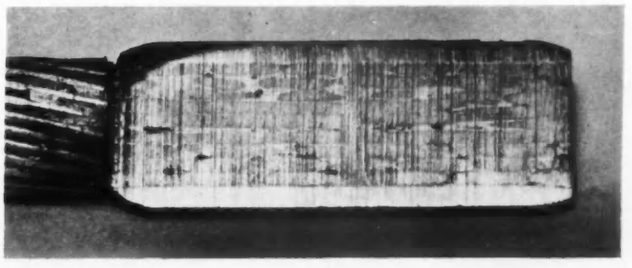

Fig. 4 Sectional view of a cable joint in the making of which Junal 5 has been used.

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CRACK DETECTION

The accompanying illustration shows a ferro-magnetic crack detector which is now being marketed by Rudkin and Riley, Limited, Cyprus-road, Aylestone, Leicestershire. It has been specially designed for testing cylinders, crankshafts, spindles and other engine parts of varying sizes and shapes. It consists essentially of two coils which are excited by direct current and adjustable supports on which the component under test can be directly mounted.

When the piece under test has been magnetised fluid is applied to it by a spray which is supplied by a pump in the base of the unit. The positions of the spray and its support are adjustable.

In order to remove the residual magnetism from the components after inspection and to assist in the extraction of iron particles from the testing fluid, the rectifier through which the necessary direct-current supply for excitation is normally obtained can be by-passed by a switch and an alternating current fed into the magnetising coils. The current consumption when the apparatus is supplied from the mains is 3 amps. during magnetisation and 4 amps. during demagnetising.

The equipment is $36\frac{1}{2}$ in. long, 19 in. wide and 46 in. high, the weight being about 174 lb

Ferro-magnetic equipment for the detection of cracks in engine parts.

DRILLING EQUIPMENT FOR MINES

HIGH SPEED AND ADAPTABILITY

A new range of compressed-air drilling equipment introduced by Atlas Copco (Great Britain), Limited, Wembley, Middlesex, was demonstrated earlier this year at Matlock Lead Mine, Derbyshire. It covers a wide variety of mining and quarrying duties, including drilling, roof bolting and roof and wall scaling.

The Atlas BBD 41 WK rock drill, which is equally suitable for benching or drifting, has a piston diameter of 2·95 in. and a stroke of 1¾ in. It weighs 50 lb. The drill has been developed from the Atlas RH 754 machine, and in drilling hard to medium limestone at Matlock it has shown itself to be 30 to 40 per cent. faster than its predecessor. The BBD 41 WK drill is designed to work at 85 lb. per square inch pressure, but it can also be used efficiently at lower pressures. The piston, rifle bar and chuck nut all have a new type of spline, with rounded grooves, giving tighter seating and longer life. There are four ratchets, providing a smooth and powerful rotation. The drill can be either hand-held, when a drilling speed of about 16 in. per minute in hard granite is possible, or it can be used with an air leg, when the speed in the same rock would be about 25 in. per minute. The standard drill has a single tube for water flushing only, but it can be equipped with a double tube for water flushing and air blowing.

For such work as short hole drilling, boulder blasting and scaling, the BBD 11 WH light jack hammer has been developed. It has a piston bore and stroke of 1¾ in. and 1⅝ in. respectively, and weighs 23·1 lb. The air consumption is only 43 cub. ft. per minute, which makes the drill suitable for operation from a portable air supply. Air and water controls are coupled, the starting of the drill being automatically preceded by the turning on of the water to flush the steel and so prevent dry collaring.

For drilling short holes, of up to 6 ft., and for numerous other types of mining and quarrying work another, lightweight machine, the BBD 11 LT, is available. It has a piston diameter of 1¾ in., a stroke of 1½ in., and weighs 18¼ lb. A rotation chuck is fitted for a steel with a hexagon shank, but, by replacing a conical spring, rotation pawl, driver and rotation ratchet, the drill can be converted for use without rotation. It is then fitted with a trimmer chisel and used with a support leg for roof and wall scaling.

In drill steels, Atlas Copco have introduced two new products, the flexible steel and the corrosion resistant type. A flexible steel consists of a flat bar 12 mm. by 26 mm. (½ in. by 1 in. approximately), which carries a tungsten carbide tip. Like ordinary tipped steels, the flexible type has a central hole for the flushing water, but it is not provided with a collar. Instead, an anvil block and rotation chuck are fitted to the drill. These steels are specially suitable for use where space is restricted, and are particularly applicable to the drilling of deep holes for sub-level caving. The second of the new steels, the SR type, has been developed by Atlas Copco and Sandvik Steel Works for improved corrosion resistance. For transport and storage purposes the collar and bit ends of the steels are provided with airtight plastic caps. It is claimed that an increase of 30 per cent. in the working life of a drill steel has resulted from the anti-corrosive treatment given to the steel.

COMBINED MACHINE FOR ROOF BOLTING

For the well-known process of roof bolting three operations are necessary; drilling the hole, expanding the bolt anchorage, and running and tightening the nut. The hole can be drilled with any suitable drill of orthodox design, and it then remains to drive the bolt home to spread the anchorage, which may be done with a hand hammer, and finally, to run and tighten the nut, for which an impact wrench is necessary.

To speed up the work of roof bolting the Atlas Copco BBD 45 WR drill has been introduced. This combines the three operations of drilling, bolt driving and nut tightening in one machine. Although similar in appearance to an orthodox stoping drill, the BBD 45 WR has several fundamental differences, notably in the direction of rotation, which is right-hand, to suit the standard threads of the roof bolts. To achieve this rotation the machine drives on the down-stroke. The rotation chuck and chuck bushing are joined together to give better resistance to the torque developed when the nut is being tightened. Water flushing is automatic, but a separate cock must be fitted to the water hose to turn off the water when driving in the bolt and tightening the nut. The drill has a piston diameter of 2⅞ in., and a stroke of 1¾ in. The total weight of the machine is 77 lb.

The work of fixing a roof bolt commences with the machine being used as an ordinary stoper with a suitable steel, in the normal way. A typical drilling time for a 6 ft. hole for a ¾ in. bolt in hard rock is about 4 minutes. When the hole is ready, the bolt, complete with its expander, is inserted, and an adaptor is fitted to the drill in place of the steel. A series of blows from the drill then drives the bolt home and expands the anchorage. Finally, when the bearer plate is in position, the nut is screwed on and a second adaptor is fitted to the drill in place of the previous one. This has an internal hexagon to suit the nut, and is designed to transmit only the torque and not the piston impact. A torque of about 250 ft. lb. is exerted. Both adaptors are available in three sizes, to suit ¾ in., ⅞ in. and 1 in. roof bolts.

The three operations of roof bolting—drilling, bolt driving and nut tightening—can be carried out with a single Atlas Copco BBD 45 WR drill and two adaptors.

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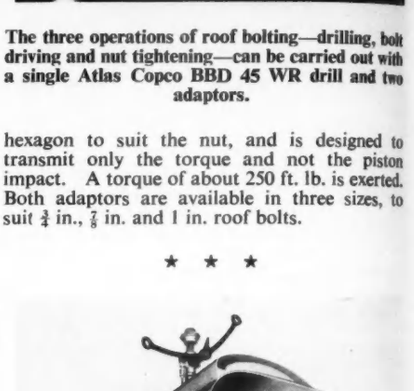


The Raymaster radiant gas heater is designed for suspending from the roof about 9 or 10 ft. above floor level.

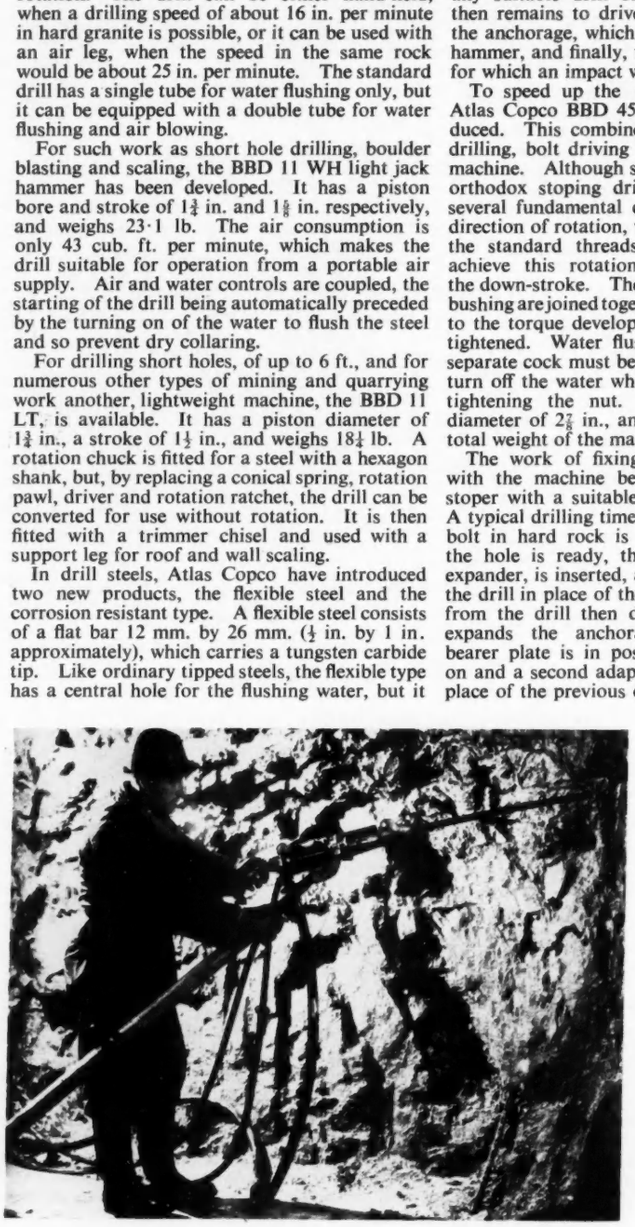
GAS HEATING

Convection and Radiation models

Two gas heaters for industrial premises have been developed by William Sugg and Company, Limited, Vincent Works, Regency-street, London, S.W.1, one of which uses assisted convection while the other relies on direct radiation. The latter, called the " Raymaster," is shown in the illustration above.

The " Halcyon " convector heater is designed for fixing on the wall about 6 ft. above the ground. Special ventilating models incorporating an adjustable fresh-air intake are made, and can be used in hot weather as air circulators by running the electric fan and not the gas heater. The fan, which normally assists the natural convection, is silent in operation.

The Raymaster is intended for use in lofty buildings and is designed to direct the maximum amount of radiant heat downwards from its point of suspension from the roof. The normal fixing height is from 9 to 10 ft. above the floor level and the gas consumption varies between 30 and 40 cub. ft. per hour according to requirements, that is, according to the weather conditions and the temperature level required in the building.



High speed drilling and economy in air consumption are the principal features of the Atlas Copco BBD 41 WK rock drill.

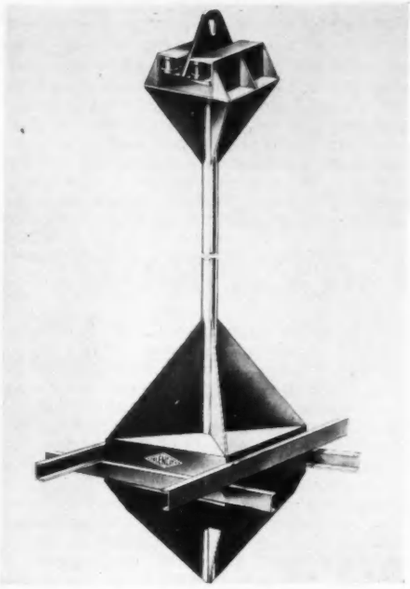
PREVENTING BLOCKAGES IN HOPPERS AND BUNKERS

Vibrator Suspended in Material

The tendency of some materials to clog, arch or otherwise block in hoppers or bunkers can often be overcome by applying vibration, sometimes only for short periods at regular intervals, in the right place. Electric vibrators fixed to the outside of a bunker, for example, may solve the problem. It is obvious, however, that the best place to apply the vibration is in the centre of the material in the bunker, where it can affect the greatest mass most evenly, and the vibrator shown in the accompanying illustration is designed with this object in view. Known as an immersion type vibratory head, it is made by the Blending Machine Company, Limited, Bond-street, Hockley, Birmingham, 19. An important feature of this vibratory head is that not only does it cause vibration at the point where it is most likely to be effective, but it can be used in a hopper or bunker which is lined in any way, as, for example, with gunite, or with tiles. External vibrators may crack the lining; the immersion type is free from this danger.

The working head consists of a fabricated frame which has a large area of contact with the material, and carries the vibratory unit, totally enclosed, in the lower part. A suspenion eye is provided at the top, for suspending the head from a joist or other suitable structural member crossing the hopper or bunker. The main body of the vibratory head is carried from the suspension eye on rubber mountings, which ensure that the vibration is kept where it is needed, and not transmitted to the bunker walls.

The normal method of control of the vibratory head is by means of a variable time switch, the cycle of working and idle time being arranged to suit the material, its moisture content, and the size of the hopper or bunker. Alternatively, control can be from a switch operated from the bunker discharge door, or by other methods according to circumstances. The vibratory head is made in a range of sizes suitable for bunkers up to 500 tons capacity. It is particularly suited to dealing with coal and coke, and will also work satisfactorily with numerous other materials; the manufacturers are prepared to advise on its use when particulars of the material are given.



This vibratory unit is suspended in the centre of a bunker or hopper, and confines the vibration mainly to the contents. Lined walls are therefore less liable to damage.

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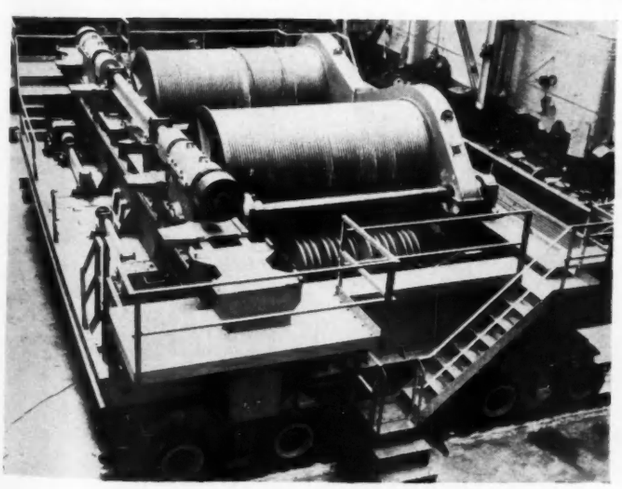
410 TON LADLE CRANE

One of the largest ladle cranes yet built has been supplied by Joseph Adamson and Company, Limited, P.O. Box 4, Hyde, Cheshire, to the Australian Iron and Steel Company. It is designed to carry a ladle weighing 410 tons and has an auxiliary crab with hooks rated for 65 and 15 tons. The span of the main crane is 75 ft. and it is carried on 24 runners, eight of which are driven. There are four 75 h.p. bridge motors, and the drive is arranged to allow some oscillation of the bogies due to any irregularities in the gantry. The main trolley was built at Hyde and is shown in the illustration; it runs on 16 wheels mounted on compensating bogies that spread the load from the two main beams. The hoist on the main trolley is of the two-motor double-gear interlocking-drum type, each of the interlocked drums mating with pinions. These are mounted on shafts at one end of which there is mounted a worm gear. One gear is cut right hand and the other left hand and each is connected to a 200 h.p. motor through a flexible coupling; the two worms are directly connected to each other by means of a line shaft and a gear-type flexible coupling. The contactor gear and resistances are built into separate compartments on the platform between the main and the lattice outrigger girder. The operator's cabin, the position of which is 43 ft. below the gantry rail, is completely enclosed and insulated, and is fitted with double armour-plate glass windows. Glass fibre wool is contained between the inside and outside walls, and the interior is air conditioned. The rate of lift of the main crab is 8·8 ft. per minute for the rated load of 410 tons and the height of lift is 43 ft. 3 in. above floor level.



The main trolley for the 410 ton ladle crane has interlocked drums driven by two 200 h.p. motors (not yet fitted in position).

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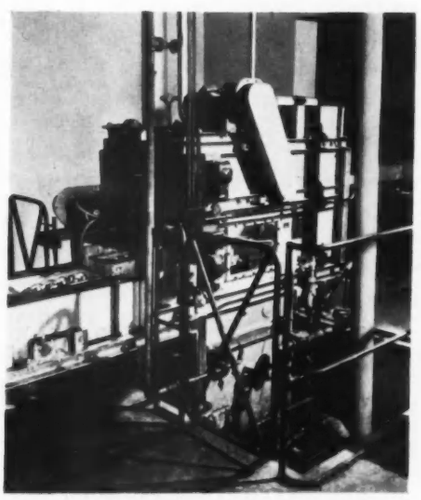
AUTOMATIC DEGREASING PLANT

In the engineering trades, mechanisation, so far, has been adopted mainly for production processes, but increasing attention is being devoted to the possibilities of adapting similar techniques to the cleaning of components. Imperial Chemical Industries, Limited, Imperial Chemical House, Millbank, London, S.W.1, have considerable experience in this field, having manufactured for more than 25 years continuous-operation metal-degreasing plants for use with trichloroethylene. A recent development in this field is a lift-type plant in which the advantages of fully-automatic operation are combined with the greatest economy in floor space. A general view of such a plant, that has been installed at the Edmonton Works of British Oxygen Engineering Limited, is shown below.

In this I.C.I. plant, work baskets move along a roller conveyor, where they are filled with components. The roller conveyor is linked up with the automatic-feed mechanism attached to the plant, and the baskets move from one to the other in their progress towards the lift platform. The entry of a basket on to the platform operates a limit switch which automatically stops the feed mechanism and sets the lift in motion. When the lift is at its lowest point of travel, it is automatically stopped and remains in this position with the work immersed either in trichloroethylene vapour or boiling liquor for a period depending upon the treatment required for the parts concerned, this being determined by a time switch. The lift rises to its former position and in doing so operates another limit switch which re-starts the feed mechanism. The next incoming basket moves the treated load of work on to an outlet roller conveyor, remaining itself on the lift platform, and the cycle of operations is repeated.



Fully automatic lift-type trichloroethylene degreasing plant for removing soluble cutting oil and brass swarf from components.

This type of plant is suitable for any work of moderate size that can be placed in a draining position in open-work baskets such as are commonly used for the transfer of components between processes. Solvent vapour diffusing into the enclosed upper part of the plant is continuously extracted, air being drawn in through the work entrance and exit, so that the escape of vapour into the shop is negligible.

The Machine Tool Industry (*continued from page* 124)

There are few species of machine tool that cannot employ automatic techniques or be fitted into flow-line production processes in some way, and forging and stamping, which is the subject of our first article this week, is no exception; an electric upsetting machine with an automatic cycle, for example, is among the machines discussed. Sheet and strip metal working, with which our second article deals, is also capable of this approach. We also summarise other features of the equipment. Earlier articles in this series have been concerned with: automatic control systems, machining light alloys, spark erosion, welding equipment, drilling, boring and milling, turning, screwing and threading, cutting fluids and slideway lubricants, furnaces and heaters, woodworking machinery, sawing, grinding, surface finishing, marking and engraving and broaching.

FORGING AND STAMPING

The production of forgings can be divided into two groups, those worked to shape by manipulation under a hammer or press, and those which are shaped in dies. Strictly speaking it is better, as is often done, to confine the term forging to the product of the "flat-faced" hammer, and to refer to the component produced in dies as a stamping. In the first group, hammer or press forgings, those produced with a hand hammer can be disregarded, as they do not involve the use of machinery and are, in any case, of very little importance to-day. The remainder can be classified according to whether they are made under a press or a hammer; even the special-purpose horizontal forging machines can reasonably be placed in one of these categories, since they operate with hammer blows. Broadly speaking, large forgings are made under a press and small ones under a hammer, though except in the case of very large forgings, which only a large hydraulic press will handle, there is much overlapping between the two groups.

Large hydraulic presses for the production of heavy forgings are made by a small number of manufacturers in this country and abroad, but they are not considered as machine tools, and none was shown at the Machine Tool Exhibition. Smaller presses, usually of the crank or eccentric type, can be and are used for the production of hot stampings, and examples of these presses, together with forging hammers, drop hammers and special-purpose forging and upsetting machines were on show during the period of the Exhibition.

HOT WORKING

Many different types of hammer have been used in the past for the production of forgings, indeed the mechanical hammer is one of the oldest of all machines, and the steam hammer is one of the best known of all the hammers. The modern counterpart of the steam hammer, which is favoured for its cleanliness, reliability and economy, is the pneumatic hammer. Two of these hammers, made by B. and S. Massey, Limited, Openshaw, Manchester, 11, are shown in Fig. 1. They represent the extremes of the range made, which is from 2 cwt. to 40 cwt. It will be seen from the illustration that the hammers are of the overhung or "clear space" type, permitting movement of men and materials through 180 deg. or more, a desirable feature which allows for the handling of forgings of difficult shapes. The hammer derives its power from an integral reciprocating air compressor, and can give single blows, controllable at will by foot or hand, or operate automatically as required. The ram can be held in any part of the stroke, or held down on the work with constant pressure.

DROP HAMMER

Machines suitable for the widely-practised hot drop stamping process are also produced by B. and S. Massey, Limited, and Fig. 2 shows their recently-developed "Marathon" drop hammer. It is particularly suitable for working to close limits, and is made in a range of sizes from 10 cwt. to 40 cwt. The hammer has balanced drive by two motors, and screw-adjusted radial V-slides giving constant clearances at all temperatures. Control is by compressed air, with a shrouded pedal fitted to a flexible hose which can be moved to suit the operator. Long or short stroke blows can be struck at will.

Stock preparation for both types of hammer can be carried out in more than one way; billets or bar stock can be sawn to length, for example, or a special-purpose shearing machine such as is shown in Fig. 3 can be used. This machine is the German-made Peddinghaus billet shear exhibited by Paul Granby and Company, Limited, 63 Chandos-court, Buckingham-gate, London, S.W.1. It will deal with mild steel billets up to 5¼ in. square and bars up to 5¾ in. diameter. The hold-down gear is of the wedge type, pneumatically operated. The machine has a fine and coarse length gauge, operates at 27 strokes per minute, and can be provided with a motor-driven feed table.

FRICTION SCREW PRESS

Another type of machine used extensively for the production of small stampings, in both ferrous and non-ferrous metals, is the friction screw press, as exemplified by Fig. 4, which shows the German Hasenclever 350 ton machine exhibited by Paul Granby and Company, Limited. This machine, the basic principle of which is too well known to need comment, has automatic push-button control, with automatic ejection, and is designed for the production of automobile engine valve forgings. Similar machines are used for a variety of hot stamping

Fig. 1 (left) Pneumatic hammers of 2 cwt. and 40 cwt. capacity, the smallest and largest in the range. (B. and S. Massey, Ltd.)

Fig. 2 Drop hammer of new design, the "Marathon," with balanced drive and compressed air control. (B. and S. Massey, Ltd.)

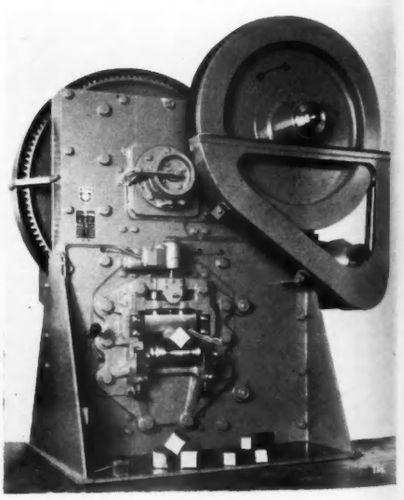


Fig. 3 (right) Billet shear for cutting billets or bars ready for forging or other operations. (Paul Granby and Co. Ltd.)

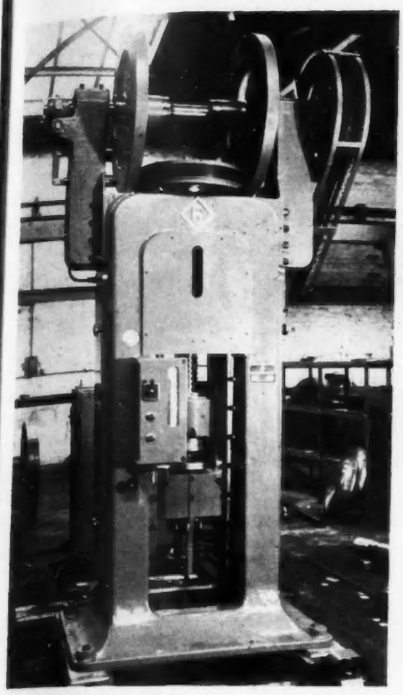


Fig. 4 **Friction screw press for producing small internal combustion engine valve forgings. (Paul Granby and Co. Ltd.)**

work, including the production of hot brass stampings for the plumbing and allied trades, and light alloy work for gas-turbine compressor blading.

HORIZONTAL MACHINES

High-speed production of small forged parts can be carried out on horizontal special-purpose machines which usually operate cold, and work from coiled stock. Such machines can be of the single blow or the double-blow type, or in some cases the blows per component can be more than two in number. In machines which strike more than one blow per component the die is moved sideways after each blow by means of a built-in mechanism, and progressive upsetting is possible. Machines of the horizontal type are confined to upsetting work, typical products being cold-headed bolts or rivets, but any other kind of upsetting which can be carried out by holding the stock in gripping dies and striking one or more blows on the exposed end can be done by the machine.

Fig. 5 shows a solid-die double-blow cold-forging machine exhibited by Greenwood and Batley, Limited, Albion Works, Leeds, 12. This machine runs at 180 r.p.m., and delivers 90 components per minute.

A new development in this type of machine is the Hasenclever dual-drive horizontal forging machine, exhibited by Paul Granby and Company, Limited. Hitherto it has been the practice to drive the gripper slide from the header slide, which meant that only about 60 per cent. of the header-slide stroke could be used for upsetting, the remaining 40 per cent. being needed to close the dies. The new machine has an independent motor, air clutch, brake and crankshaft for driving the gripper slide, an arrangement which allows of a higher operating speed.

UPSETTER WITH AUTOMATIC-CYCLE

One other Hasenclever machine, exhibited on the Paul Granby stand, is worthy of special mention. This is the electric upsetter, which operates on a fully automatic cycle, started by placing the workpiece in position. The machine is completely self-contained, requiring no foundation other than a level floor and is tapered from front to back to enable several machines to be grouped in a semi-circle round a finishing press.

TRIMMING

The components produced by the various types of machine mentioned have one thing in common, they will all require some further treatment before they are ready for use. Some, like certain smith-made forgings produced under the hammer, may need only a small amount of machining, while others will have to be machined all over. All drop-stamped products, and some others as well, will have to be trimmed of their "flash," and for this purpose it is usual to employ a crank-type trimming press, such as was shown by B. and S. Massey, Limited. This machine, which is similar in appearance to crank presses, is equipped with a die having a straight-through hole of the size and shape of the finished stamping, and a punch which pushes the stamping through the die to trim off the flash.

The Machine Tool Industry

SHEET AND STRIP METAL WORKING

Sheet and strip metal have one common characteristic—relatively large width compared with their thickness. Comparatively speaking sheet is wide and strip is narrow, but no generally-accepted definition exists which will place a dividing line between the two. What is more important from an engineering point of view is that both can be worked by the same methods, and often by the same machine. A comparatively new feature of the sheet and strip metal working industries is that larger and heavier coils of strip are now available, and sheets, which used to be obtainable only in the cut form, can now be purchased in continuous coil form. They are often so bought, and are cut to length as required by the user.

MATERIAL PREPARATION

Both sheet and strip will need some form of preparation before they can be worked in power presses or other forming machinery. The preparation may vary from simple cutting to size by shears to blanking in a press. Straightening may be necessary, especially if the material is received in coil form, and some type of flying shear may be used to cut up the continuous lengths of material.

Some strip metal working machines incorporate straighteners and other equipment, but a standard power press can be adapted quite easily to operate automatically from coiled stock by the addition of auxiliary equipment such as

Fig. 1 **Power-driven combined decoiler and straightener. (Humphris and Sons, Ltd.)**

was shown on the stand of the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware Road, London, N.W.2. A typical arrangement would consist of: a stock reel, which has a friction brake to put the necessary tension on the strip; a straightener of the multi-roll pattern and a slide feeder, which grips the strip and feeds it forward to the press in the lengths required. The line might be completed by a powered stock reel for winding scrap and an oiler for applying oil to the strip as required for the subsequent operation in the press. A scrap cutter might be used instead of the stock reel in certain cases.

Straighteners, which operate on the well known multiple-roll principle, may be used without power drive, stock being drawn between the rolls by the feeder, but powered types are available; these are especially suitable for dealing with short lengths of material.

HANDLING LARGER COILS

A noticeable feature in what might be called preparatory equipment is the development in recent years of heavier machinery, which will not only handle bigger coils and thus permit longer production runs between stock changes, but are also designed for rapid and efficient stock handling. The power-driven combined decoiler and straightener shown in Fig. 1, and made by Humphris and Sons, Limited, Poole, exemplifies this trend. The machine is provided with a hinged ramp which can be used for rolling the stock coil into position. When it is raised,

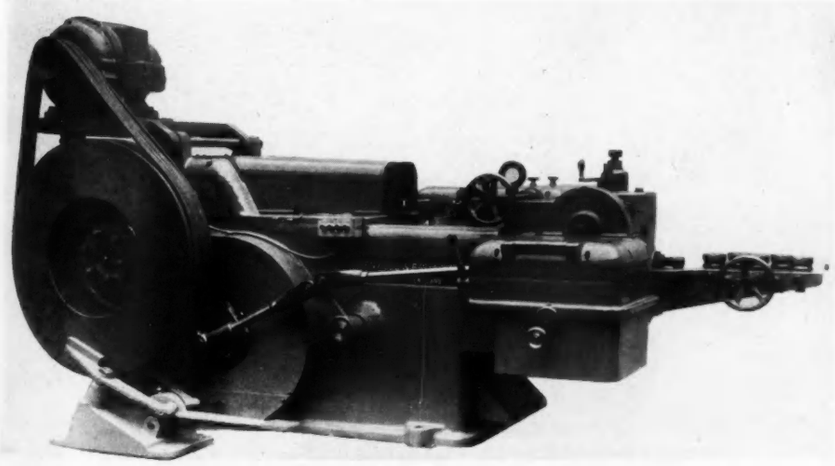


Fig. 5 **Solid-die double-blow cold forging machine. (Greenwood and Batley, Ltd.)**

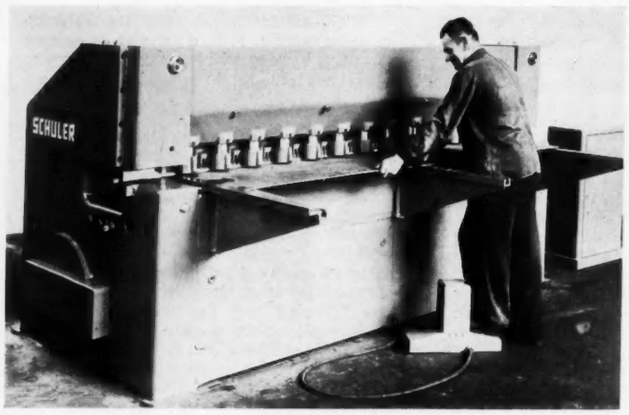


Fig. 2 Totally-enclosed guillotine shear with hydraulic sheet-holder. (Pearson Panke, Ltd.)

the ramp acts as an effective means of preventing danger from the tail of the coil, which might spring outwards as the material becomes exhausted.

The coil can equally well be loaded by fork-lift truck or overhead crane. Quick entry of the leading end of a new coil into the straightener is effected in the usual way by means of a hand-lever operated cam which opens the leading rolls. The unit is transportable, and can thus be used with any press or other machine as required.

SHEARING

A common machine used in sheet metal working is the guillotine shear, which may be a very simple unit, perhaps foot-powered in the smaller sizes, or a more elaborate, power-driven machine such as the German Schuler 8 ft. by ¼ in. shear shown in Fig. 2. This machine, exhibited by Pearson Panke, Limited, 1–3 Hale Grove-gardens, London, N.W.7, is totally enclosed, the drive mechanism being in the base and the connecting rods for the upper beam in the uprights. It is controlled by an electro-magnetically operated friction clutch, and has hydraulic hold-down for the material being cut.

Machines of this type are effective with straight-line cuts; for curves and irregular shapes other machines are necessary. The rotary shear, for example, which consists of a pair of rotating cutters, can be used for hand-guided line cutting, or a sheet of metal can be power-rotated from a centre at the required distance from the cutters to produce a disc.

A different type of curved and irregular line cutting machine is the nibbling shear, of which examples were shown by F. J. Edwards, Limited, 359-361 Euston-road, London, N.W.1. This type of machine operates by means of a pair of reciprocating cutters moving in a vertical line, which split a sheet of metal as it is guided into the cutting area. The actual cut at each stroke being very short, the nibbler can be used for cutting along lines which have very small radii or sharp corners.

POWER PRESSES

There are two basic groups of power press, hydraulic and mechanical, the latter including the crank, eccentric and toggle types.

Hydraulic presses are usually, though not invariably, of the self-contained type, with built-in pump and control gear, and form a compact unit. They are made in a very wide range of sizes, and vary from simple manually-controlled units to automatic-cycle machines particularly suitable for deep drawing. A small press, made by Hi-Ton Machine Tools, Limited, Birmingham, and shown by Drummond-Asquith (Sales), Limited, King Edward House, New-street, Birmingham, 2, is illustrated in Fig. 3. This press, which has a capacity of 30 tons and a stroke of 21 in., is one of several adaptations of a basic design, which include indexing tables and mechanical feeds. Presses of this type are adaptable to many different kinds of operation, including some such as straightening, sub-assembly and ceramic moulding.

A larger press, one of the German S.M.G. range exhibited by Pearson Panke, Limited, is shown in Fig. 4. This machine is designed for deep drawing, and has an integral, infinitely-variable delivery pump, which gives full control of rate and direction of travel without the use of control valves. The press is made as a single, double or treble-acting type, and the closing, drawing and return speeds can be selected independently. The cycle is automatic set.

Mention must also be made of the German Lasco hammer press shown in Fig. 5. This machine, exhibited by Paul Granby and Company, Limited, 63 Chandos-court, Buckingham Gate, London, S.W.1, combines the action of a hydraulic drawing press with that of a hammer. As a drawing press it has the normal hydraulic cycle, approach, draw and return, any part of which is infinitely variable. In addition, the press can be used as a hydraulically-raised drop hammer by operating a single lever.

MECHANICAL PRESSES

Mechanical presses of the crank, toggle or eccentric type cover such a large range in both constructional detail and capacity that it is only possible here to mention a few typical examples as shown at the Machine Tool Exhibition. The very large presses, such as are included in the British Clearing and Wilkins and Mitchell ranges, were too large to be exhibited, but both ranges were represented by smaller machines. The Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, showed British Clearing presses of the single-action type of 250 and 350 tons capacity, and the exhibits of Wilkins and Mitchell, Limited, The Green, Darlaston, South Staffordshire included a 350 ton single-action crankless press of the tie-rod type, and a 200 ton crankless stripping and setting press of fabricated steel solid frame construction.

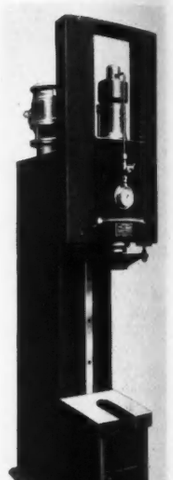


Fig. 3 Small hydraulic press of 30 tons capacity. (Drummond-Asquith (Sales), Ltd.)

In the lighter ranges of power presses an example is provided by Fig. 6, which shows a 25 ton inclinable crank press made by

Fig. 4 Hydraulic deep drawing press with variable-delivery pump. (Pearson Panke, Ltd.)

Fig. 5 Hydraulic drawing press which can also be used as a gravity hammer. (Paul Granby)

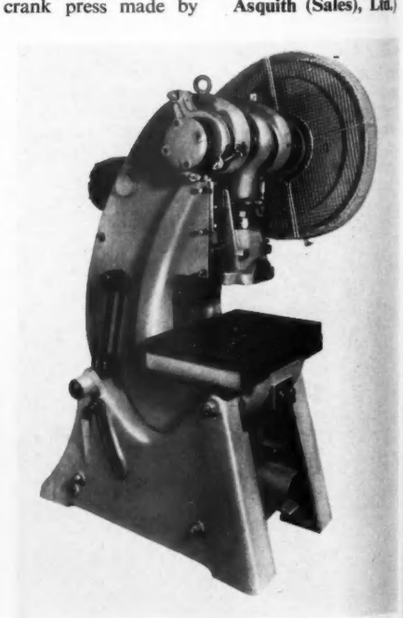


Fig. 6 Inclinable crank press of 25 tons capacity. (Humphris and Sons, Ltd.)

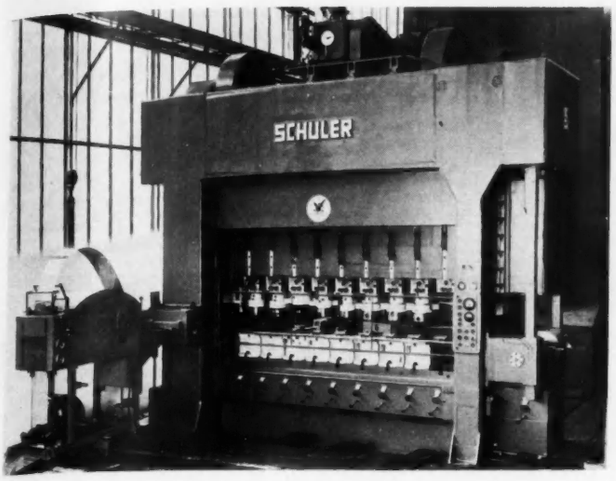


Fig. 7 Transfer feed press with nine tool stations and alternative feeds from coil or stacked blanks. (Pearson Panke, Ltd.)

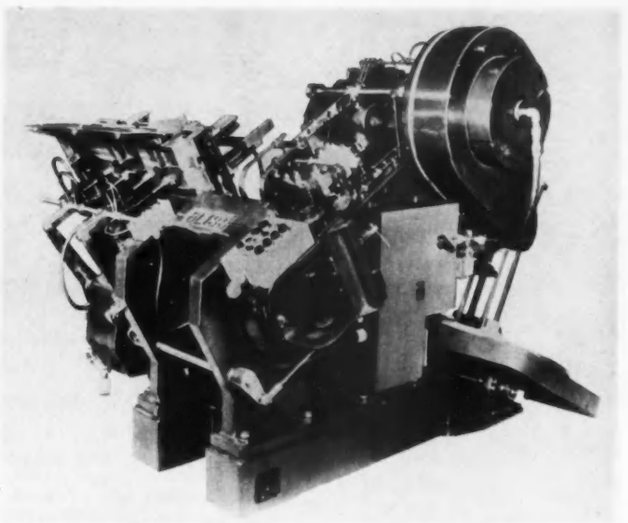


Fig. 8 Automatic strip feed press with an output of 600 components per minute. (E. W. Bliss (England), Ltd.)

Humphris and Sons, Limited. In power press design the emphasis in recent years has been on higher speeds of operation, which has not only involved an increase in the use of power feeding devices, but has also affected the basic design of the press. Clutches, for example, are tending to change, the friction clutch finding increasing favour at the expense of the old mechanical type which will not run at the speeds required.

The field of automatic operation is virtually unlimited, and in some forms it is quite old. The transfer feed press, for example, ranks as one of the oldest forms of mechanisation in use to-day, but it still has many applications and is, in fact, on the increase. An example of modern design in this type of press is provided by the German Schuler transfer feed press shown in Fig. 7. Exhibited by Pearson Panke, Limited, this press has nine tool stations, and has unusual feeding equipment, which enables it to work either from coiled stock or from an automatic feed using stacked blanks.

STRIP FORMING

The normal power press equipped with a reel for coiled stock, straightener, and roll or slide feed can be used for a great variety of work on strip metal. It is also possible to modify the design of the press with the object of working from strip only at high speed, and the press then becomes a unit in a complete machine. Such a machine is the strip-feed press made by E. W. Bliss (England), Limited, City-road, Derby, and shown in Fig. 8. This machine, designed for producing metal can ends, will make 600 components per minute. As will be seen from the illustration, the machine is based on an inclinable crank press, but it is designed and built as a complete unit with the feed mechanism.

An entirely different type of machine which works on strip (and can also, with some small modifications, be used on wire), is the slide machine made by Heenan and Froude, Limited, Worcester. This machine is is of the horizontal type, with built-in straightening rolls and feed mechanism. It has four forming slides, which can be used for bending, folding or otherwise shaping the component being produced, and an independent horizontal press between the slide station and the feed mechanism, which can be used for any normal pressing operation. Numerous methods of setting-up can be employed, and there are extra attachments available to increase the versatility of the machine. A new feature is the provision of a shaped Perspex guard which enables the operation of the machine to be observed at all times, and is suitably interlocked for safety purposes.

A completely new development introduced by Heenan and Froude, Limited, is the hydraulic " multiform " machine shown in Fig. 9. Basically the same as the older mechanical machine the new model is entirely hydraulic, the only mechanical movements being those of the actual forming slides themselves. Control of the slides is by a fluid-driven camshaft and servo-valves. The cams are only under very light pressure from the followers, and they need not be hardened, consequently they are cheap to make and can undergo final adjustments by filing in position. A complete set of cams and their shaft can be removed from the machine and stored ready for re-use without re-setting at any time. It is thus a quick and easy matter to change the machine from one type of production to another.

SHEET METAL FORMING

Sheet metal can, of course, be formed in power presses, and much of the production of sheet metal components is carried out in such machines. There are however, other machines for sheet metal forming, which can be used for " one-off " jobs or production runs. They include the rolls on which cylinders or parts of cylinders and cones are formed, and press brakes or folding presses. Rolls call for little comment. They are made in a range of sizes, from small hand-powered machines for light sheet metal work to large machines for working heavy plate, which cannot be considered as sheet metal machines at all. The basic types are well-established, and no fundamental change in design has taken place in recent years.

Folding presses, like rolls, cover a range of metal thicknesses which in the larger sizes take them right out of the sheet metal range, and in the smaller include hand-powered models. By the use of suitable tools it is possible to form

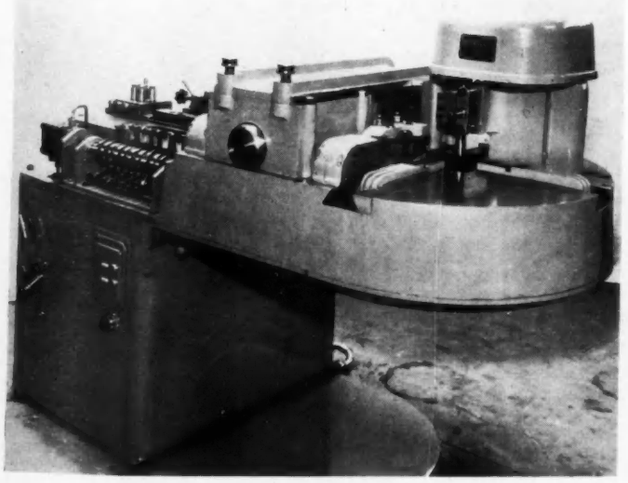


Fig. 9. Hydraulically-operated " multiform " strip forming machine. (Heenan and Froude, Ltd.)

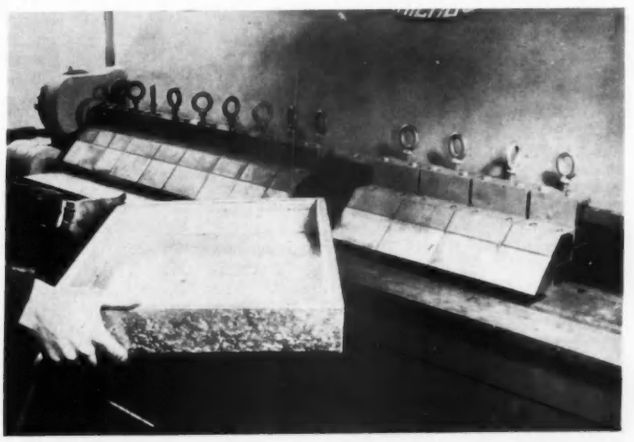


Fig. 10 Box folded from sheet metal in press brake. (Oliver Machinery Co. Ltd.)

Fig. 11 Focker-Eckold sheet metal forming machine which works by shrinking or stretching. (Alfred Herbert, Ltd.)

on these machines any kind of bend up to and beyond a right angle, and to work to small radii when necessary. An adaptation of this type of machine, the box and pan brake, enables boxes and similar shapes to be folded on all four sides. An example of this type of work, done on the American Chicago machine, exhibited by the Oliver Machinery Company, Limited, 196 Deansgate, Manchester, 3, is shown in Fig. 10.

METAL SHRINKING AND STRETCHING

A more recently developed technique for forming sheet metal, which is capable of producing complicated shapes, is that of shrinking and stretching. Neither of these operations is new in itself, but shrinking in particular has hitherto been regarded as a corrective measure for removing wrinkles from sheet metal pressings.

Two types of machine for shrinking and stretching were shown at the Machine Tool Exhibition. The D.F.S. machine, exhibited by Robert Kelly and Sons, Limited, 55 Market-street, Manchester, 1, is hand-operated, and is capable of working mild steel up to 18 s.w.g. In appearance not unlike a small hand press, the machine has a pair of tools which grip the metal surface and then move together and tilt simultaneously in relation to each other in a radial action. This causes the contact distance to decrease and so effects a shrinkage of the metal under the jaws. The metal is then released and the operation is repeated until the desired form has been given to the component. The machine can be changed to stretch metal quite quickly by changing the tools.

Alfred Herbert, Limited, P.O. Box No. 18, Red Lane Works, Coventry, had on exhibition the Fokker-Eckold universal sheet metal shaper, as illustrated in Fig. 11. The machine has two identical tools, the upper one being vertically-adjustable but stationary in operation, while the lower one reciprocates. A motor-driven eccentric shaft and push-rod give a constant speed of 300 strokes per minute to the lower tool. Contact between the tools and the work is made by lifting the lower tool and applying the required pressure. In the machine illustrated, control of the lower tool is by means of a tilting foot switch and a servo-motor, which gives "inching" control over the total movement of 5 mm. A multi-speed pole-change motor enables the operator to

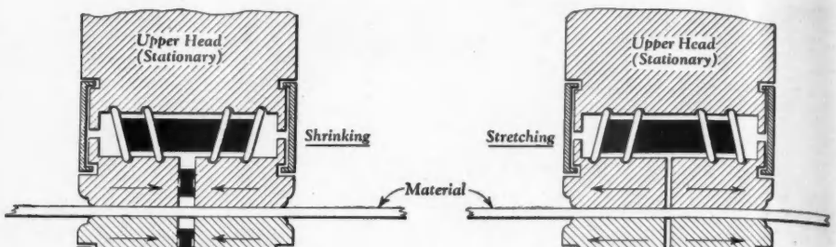


Fig. 12 Diagrammatic sketch of tools for metal shrinking and stretching. (Alfred Herbert, Ltd.)

select one of three speeds according to the thickness of material being worked, which, in the machine illustrated, may be up to a maximum of $\frac{5}{32}$ in.

Fig. 12 shows the principle on which the tools operate. Each consists of a core body, rubber bonded lamellae or steel strips which provide the shrinking or stretching motion, a jaw-holder in halves with jaw plates and a retaining clip in halves. A rubber strip is inserted between the jaws of the shrinking head to act as a cushion and prevent the ingress of foreign matter. Once the tools are in contact with the material and under sufficient pressure the lamellae deflect and cause the jaw holders and jaws to move in a horizontal direction, inwards when shrinking and outwards when stretching. As the jaws move they grip the material on both sides, shrinking or stretching it locally, and as the action is repeated 300 times per minute, the required shape can therefore be worked into the component relatively quickly.

A smaller machine is available for dealing with mild steel up to 0·10 in. thick and other metals in proportion. There is also a small hand-operated machine for light jobbing work. The power machines can be fitted with a universal edge-shaping unit which has a pair of heads, for shrinking and stretching, mounted in place of the normal pair of tools.

ATOMIC REVIEW

Year in Retrospect

On July 25 the United Kingdom Atomic Energy Authority presented its second annual report covering the period April 1, 1955, to March 31, 1956. This week, therefore, we shall devote the Atomic Review almost exclusively to information revealed in the report, covering such topics as Authority staff, uranium extraction and fuel-element fabrication, and reactor technology.

Personnel

In October last year, Mr. W. Strath, C.B., was appointed a full-time member of the Authority. He is largely concerned with the Authority's relations with industry and overseas atomic energy organisations, and with raw material procurement. At the same time, Sir Rowland Smith, Chairman of the Ford Motor Company, and Mr. C. F. Kearton, a director of Courtaulds Limited, became part-time members. Mr. Benson Gyles has been appointed to act as a liaison officer with industry, and to advise on the uses to which Authority inventions may be applied. In addition, during the year, the Authority's non-industrial staff increased by 30 per cent., and the industrial staff by 13·6 per cent., this brought the total staff up to 23,973 by March 31 this year.

Uranium Ores

As we previously reported (see ENGINEERING, July 13, page 61), there has been a spate of new uranium discoveries during the year, most of them on the North American continent. These discoveries have been so extensive that they have removed the danger of a world-wide shortage, but as the world supply position becomes easier some attention has to be paid to the relative cost of production from new deposits; there is no question, the report states, of paying almost any price for uranium. The forecast made in September, 1954, by the Director of the Raw Materials Division of the U.S. Atomic Energy Commission, that the acceptable price for uranium contained in a high grade concentrate might become about 10 dols. (71*s.* sterling) per pound, has already received some confirmation.

For their current uranium imports the Authority have continued to depend on contracts placed by the Combined Development Agency on behalf of the Authority and the U.S. Atomic Energy Commission. The following developments concerning agency contracts are of interest. In Australia the first shipments of concentrates have been received from the mines at Rum Jungle and Radium Hill. A plant erected at Port Pirie on the Spencer Gulf to treat the Radium Hill output was opened in November, 1955. The supply of uranium ore and concentrates from the Shinkolobwe mine in the Belgian Congo is expanding, while the output of uranium concentrates from the Transvaal and Orange Free State mines, South Africa, also continues to grow. During the year the Authority entered into loan agreements with five gold-uranium producers.

In order to secure the additional imports which will be needed in the future a number of contracts for delivery of uranium directly to the U.K. have been or are being negotiated. We have already referred to the contract signed with Mary Kathleen Uranium Limited (ENGINEERING, vol. 181, page 245, 1956) under which uranium from a mine in Queensland, Australia, situated some 500 miles from the coast at Townsville and about 40 miles from Mount Isa is to be purchased. The Authority have also entered into a commitment in regard to the deposits of the South Alligator region in the Northern Territory, but so far, although interesting mineralisation has been discovered, uranium deposits have not justified erection of a treatment plant. Finally, the authority have, during the year, taken steps to foster an interest in uranium

prospecting in the central African Federation, which is geologically promising but where no rich strike has yet been made. (ENGINEERING, July 13, page 61.)

Uranium Extraction and Fabrication

Once uranium has been mined, the ore, which probably contains only a fraction of 1 per cent. of the metal, has to be treated so as to provide a chemical concentrate with a minimum of 50 per cent. uranium as the feed material for the Authority's chemical and metallurgical plant at Springfield. One of the chemical techniques used in concentrating the uranium is the ion exchange process originally developed for softening water.

Chloride extraction employing cheap materials and simple techniques has also played a part in obtaining thorium, uranium and beryllium and seems capable of operating on a large scale. The production of uranium metal has been increased to meet the requirements of Calder Hall and to maintain supplies to the existing reactors; for this reason increased quantities of uranium hexafluoride have been produced for the gaseous diffusion plant. In addition to virgin material brought into the uranium production plant at Springfield during the year a large accumulation of slags and other materials produced in the uranium purification process have been treated for the recovery of their uranium content. Uranium depleted in the 235 isotope through irradiation has, following treatment in the Windscale chemical separation plant, been converted to the hexafluoride for re-enrichment in the gaseous diffusion plant at Capenhurst, the facilities of which have been extended to meet demands for additional separation capacity. It was decided that the first stage in the modernisation of the uranium extraction plant should be to change from calcium to magnesium as the means of reducing uranium tetrafluoride to metallic uranium. This, it is believed, will lead to considerable saving in raw-material costs. The aim of development work on other sections of the process is to introduce continuous operation in place of batch working.

New equipment has been installed and brought into operation to make cartridges for the Calder Hall reactors. The greater length of these cartridges and the greater strength needed to enable them to be stacked in vertical channels are two features which have raised manufacturing problems; these are being overcome.

Solid fuel elements for a nuclear reactor must be enclosed in a gas-tight can to prevent escape of the highly radioactive fission products; in addition the contact between can and fuel must be tight in order to permit efficient heat transfer to the cooling media. A method using beryllium powder is described below. Another involves a cold hydrostatic pressure technique similar to that used in making cold-pressed thorium bars, also described below. This avoids the complication of pressing at high temperature and gives a better bond between the fissile material and the can. Satisfactory bonding between uranium rods and zirconium cans has been achieved both by extruding the two together and also by casting the uranium directly into the can. Chromium plated precision moulds have been developed which allow use of cast uranium rods without further machining. Fabrication of enriched uranium elements clad in aluminium for the DIDO class reactors has proceeded satisfactorily Elements using uranium oxide in aluminium are being developed for use with low-enrichment uranium.

The industrial group is also carrying out investtigations on the metallurgy of fuel and canning materials on some of the metals which may be used for sheathing fuel such as niobium and vanadium. It has been necessary to begin by developing methods of producing the metal in a ductile form suitable for forming to the required shape and subsequently examining it for such physical properties as creep strength, thermal conductivity and compatibility with uranium and sodium.

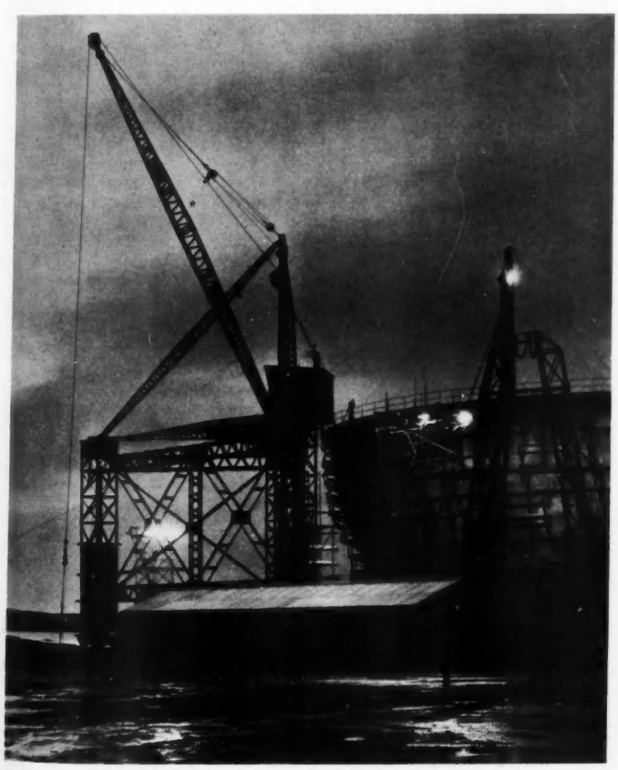


Fig. 1 The lower half of the steel protecting sphere for the fast breeder reactor at Dounreay has been completed. A bowl 70 ft. high and 140 ft. across, it is larger than the dome of St. Pauls. The Dounreay reactor will provide medium-power electrical output, and should be operating for experimental purposes, including plutonium breeding studies, by 1959.

Other Materials

The immense demand for graphite arising from the construction of graphite-moderated reactors has compelled the Authority to create additional capacity for producing the high-quality high-purity material required. British Acheson Electrodes, Limited, will contribute to this expansion.

Both beryllium and beryllia are now being made in Britain on a pilot-plant scale, and a new and simple technique has been developed to produce pure beryllium powder from the raw products; the powder can then be used for fabrication of the necessary shapes required in reactor work by powder-metallurgical techniques. A method which avoids the porosity introduced by normal sintering has been devised to produce a homogeneous mixture of beryllium and fissile material. Another step has been the production of uranium fuel elements clad with beryllium by a sheath forging technique, using beryllium powder—thus avoiding the difficulty of welding this material—to produce a gas-tight envelope with very good heat-transfer properties. Beryllium oxide shapes are now being fabricated by a hot-pressing method which gives an enhanced bulk density of value in a reactor moderator.

Thorium metal has a high melting point, consequently it is difficult to select crucible materials and avoid contamination if the normal methods of fabricating bars or other shapes by casting are used. A technique which has been developed avoids the fire and health hazards consequent on dealing with this material at high temperatures. In this process thorium powder is inserted into a rubber tube, sealed at each end; the tube is then subjected to high pressures in a hydraulic press and a bar produced by cold pressing. The bar may then be sintered to increase the bulk density and can be swaged to the desired diameter without machining. The efficiency of this process, that is the amount of metal extracted from a given output, is very high—98 per cent. Tubes and plates may also be produced in this way and mass-production techniques employed.

The use of conventional aluminium alloys in water-cooled reactor systems is difficult because of high corrosion rates at the temperatures involved. A new class of alloys of aluminium with iron, nickel, silicon or titanium (" Aereal " alloys) is being developed to resist corrosion in water at high temperature and pressure.

Reactor Programme

As has already been stated there are at present three stages in the Authority's reactor research programme: research on Stage 1 includes study of the reaction between carbon-dioxide coolant and graphite at the envisaged operating temperatures and is being performed in a testing loop in BEPO. Much of the work is devised to discover improved canning materials and fuel elements so that higher temperatures may be achieved in future reactor designs. This aim to obtain higher operating temperatures is very important and may account for recent statements that future reactors will be much more efficient than had been anticipated.

For Stage 2, feasibility studies and research and development work are being carried out on the pressurised-water reactor and the sodium-graphite reactor. These would provide higher heat ratings than gas-cooled reactors, but would require enriched fuel. A number of loops have been built to study the corrosion of carbon steels and stainless steels under the conditions likely to be experienced in pressurised-water reactors. One of these loops was being installed in the Canadian NRX reactor at the end of the period under review. Another has been operating in BEPO for some time and a further loop will be installed in DIDO. Fuel element specimens using highly alloyed uranium and the more corrosion-resistant uranium oxide have been made and are being investigated for irradiation damage, while zirconium alloys have been developed for canning the fuel elements. Development work is also being carried out on aluminium alloys for sheathing the fuel elements. If successful, this would reduce their cost greatly below the cost of elements using Zircalloy. The use of organic liquids such as diphenyl and terphenyl as an alternative to the water moderator and coolant is being investigated. Their stability under irradiation looks promising. If such liquids could be used the system pressure would be much lower and corrosion problems might be less severe. Another method of reducing the pressure is to use a boiling water system, and this alternative also has been studied.

Reactor physics and metallurgical and engineering investigations are being carried out on the alternative reactor using graphite as a moderator and liquid sodium as a coolant. This system would have the advantage of permitting higher temperatures and therefore higher thermodynamic efficiencies. The pressure of the system would also be lower than that of the pressurised-water reactor system. In this reactor the liquid-sodium coolant must be prevented from penetrating the graphite. One method of

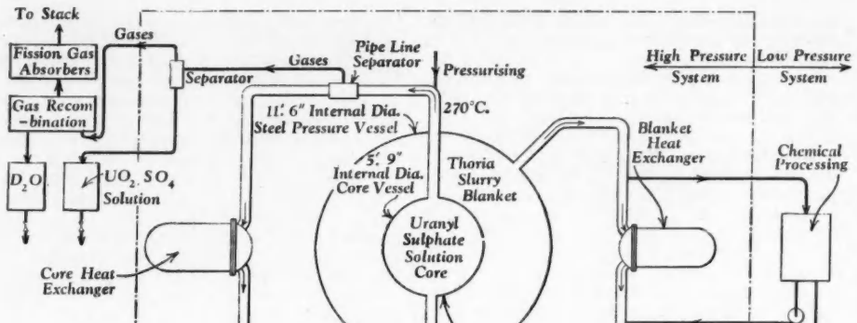


Fig. 2 Diagrammatic layout of an aqueous homogeneous reactor system, by which breeding can be achieved in the uranium 223-thorium cycle, with continuous processing of fuel and fission products.

achieving this is to can the graphite blocks in hafnium-free zirconium sheet. This requires study of the compatibility of liquid sodium with zirconium. Another method would be to seal the fine pores in the graphite. The reactor physics is being investigated to determine the degree of uranium enrichment required and the overall economics of the fuel cycle. A zero energy system is being constructed. If these studies show one of these reactors to be more economically favourable than Stage 1 reactors, the Authority expect that design work on a prototype will be started by the end of 1956. Present information suggests that the choice will probably fall on the sodium-graphite system. This prototype will be additional to the twelve stations planned for operation by 1965 in the White Paper programme.

One major objective of Stage 3 is to attain a much higher fuel utilisation by the achievement of breeding. Four reactor systems are being investigated, in addition to the organic system already mentioned: (i) the fast reactor system, (ii) the homogeneous aqueous reactor system, (iii) the liquid-metal fuelled reactor system, and (iv) the high-temperature gas-cooled reactor system. The zero-energy fast reactor, ZEPHYR, was in operation throughout the year. The experimental programme centred mainly around the investigation of breeding characteristics of the plutonium-uranium system and the determination of the nuclear properties of many materials in fast reactors. The best data available for the neutron economy in ZEPHYR indicated that a breeding ratio of about 2 was obtained in the ideal conditions of a small uncooled system, that is, the reactor produced about twice as much fuel as it consumed. "Delayed neutron" emission from the fissile isotopes and from uranium 238 and thorium 232 in fast fission was also studied and the results related to the kinetic behaviour of ZEPHYR. During the year, ZEUS, the zero energy version of the Dounreay fast reactor which is shown under construction in Fig. 1, was built, and came into operation on December 22, 1955.

The lower half of the protecting sphere for the Dounreay reactor has been completed, as can be seen from Fig. 1. The next stage is the construction inside it of the concrete vault, 80 ft. in diameter, which will contain the reactor core, the breeding blanket and the reflector which surrounds the core. Outside this will be primary heat exchangers (see ENGINEERING, vol. 181, page 283, 1956). Sea-water will be used for condenser cooling, thereby dispensing with cooling towers.

The purpose of the aqueous homogeneous reactor is to achieve breeding in the uranium 233-thorium system, and by this means to achieve very low fuel costs. A layout of the system is shown diagrammatically in Fig. 2. Work on the effects of irradiation on the stability and corrosiveness of uranium solutions at high temperatures and pressures, and on methods for the continuous removal of fission products from these solutions has been carried out, and studies of high-pressure pumped loops, one of which will go in BEPO and the other in the new reactor PLUTO, have been started.

Zero energy critical assemblies (known as ZETR) have been made with both fissile isotopes of uranium (uranium 233 and 235) in order to check nuclear physical calculations of critical size, flux distributions and temperature coefficients. An assessment of a power reactor generating about 100 MW of electricity has also been prepared to bring out the outstanding problems for which design data should be obtained through a reactor experiment. Small-scale investigations have been continued into fused salts which will dissolve uranium compounds and might be used as fuel in very high temperature homogeneous reactors. Some promising systems are now being studied in detail and with special regard to corrosion and radiation stability. A homogeneous reactor system is shown diagramatically in Fig. 2.

An alternative to the aqueous homogeneous reactor as a thermal breeder is a reactor using a graphite moderator and a fuel consisting of enriched uranium dissolved in a liquid metal. Such a reactor would have the fuel processing advantages of an aqueous homogeneous reactor combined with a relatively high output temperature. High pressures in the coolant circuit, which are necessary in aqueous systems because of the high pressure of the fluids, would be avoided. Reactor engineering studies in the past year have shown that the best system for the thermal reactor is likely to use a fuel consisting of a solution of uranium 235 in bismuth. The reactor core would be surrounded by a "blanket" of a thorium-bismuth compound suspended in bismuth as a slurry. In this way neutrons which would otherwise escape from the core may be captured in the fertile material thorium to produce fresh supplies of the fissile material, uranium 233. Metallurgical studies are in progress on the handling and purification of bismuth and its alloys, and on the selection of corrosion-resistant containers. A loop in which bismuth can be circulated has been inserted into BEPO, and it is planned to put a further loop into PLUTO to simulate circulation in a power reactor.

The achievement of very high outlet temperatures (of the order of 750 deg. C.) would greatly increase the thermal efficiency of a reactor system, and would make possible the use of gas turbines as a means of extracting the energy from the system. To achieve these temperatures, gas-cooling would be necessary. The feasibility of such a system is being studied.

It is probable that one or two of the Stage 3 reactors will be chosen in 1957-58 to proceed to a reactor experiment. This would consist of a relatively low power reactor which would be designed to test the general technology of the system and to allow attention to be paid to its possible application to the development of medium power output nuclear power stations. Such stations, in the region of 10 MW output, would be more suitable for export to many countries than the larger stations of the type being developed for the electricity authorities in the United Kingdom.

The progress of this programme depends to a very great extent on the use of materials testing reactors, one of which, DIDO, has recently been completed and will probably be put on to full power by Christmas. There has been considerable difficulty in meeting completion dates of the various items, due partly to the generally overloaded capacity of sub-contractors. But by early 1957, a high-pressure water loop and high temperature gas-loop will be installed for detailed investigation into possible reactor systems using these coolants. Fig. 3 shows workmen at Harwell installing the graphite reflector in DIDO, which is to be officially opened in September, 1956. PLUTO, a 10 MW heavy-water high-flux reactor, should be completed by September, 1957, and available for use early in 1958. A duplicate of PLUTO is to be built at Dounreay.

Other items dealt with in the report will be covered in subsequent Atomic Reviews under appropriate headings.

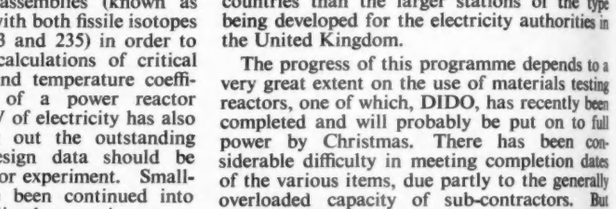


Fig. 3 Workmen installing the graphite reflector in the 10 MW materials testing reactor DIDO in January this year. The reactor is expected to be up to full power by next Christmas.

In Parliament

ESCAPES FROM SUBMARINES

Recent progress in methods of effecting the release of personnel trapped in sunken submarines was referred to in a question in the House of Commons last week. Mr. George Ward, the Parliamentary and Financial Secretary to the Admiralty, told Surgeon Lieutenant-Commander R. F. B. Bennett (Conservative) that the methods of escaping from submarines in that condition have been reconsidered in the light of the most recent progress. A method has now been developed by which men trapped in a sunken submarine can effect their escape in rapid succession in immersion suits, by floating to the surface through canvas trunks which extend down into the submarine from escape hatches. A system of providing purified air to the men before they escape is built into the vessel.

Mr. Ward said that trials had shown that this method provided the best chance of escape from depths down to 200 ft., and that it had accordingly been decided to fit all existing and future submarines with this system. In addition, future submarines would be fitted with a hatch at each end, to which a rescue bell could be attached by rescuers working outside the vessel. The use of that method was limited, because it depended upon the presence of a ship with a rescue bell; but it could be employed at depths exceeding 200 ft.

Another point to which Mr. Ward referred was that more extensive trials of the one-man escape chamber, previously intended for new submarines, had shown that system to be inherently unreliable when needed. Its performance was unlikely to match the weight and space requirements which it imposed. Further development work on that device had accordingly been abandoned.

FUTURE OF H.M. DOCKYARDS

Mr. J. J. Astor (Conservative) inquired about the extent to which the economy measures proposed by the Chancellor of the Exchequer were likely to affect the number of industrial workers employed at Devonport Dockyard. He was informed by Mr. S. Wingfield Digby, the Civil Lord of the Admiralty, that, so far as could be foreseen at present, these economies were not expected to involve any discharges of industrial employees from that dockyard. In answer to a similar question, by Mr. W. W. Hamilton (Labour), the Minister stated that, so long as naval commitments remained substantially as at present, no change was likely to take place in the functions of H.M. Dockyard at Rosyth.

ELECTRICITY FOR DISTRICT HEATING

Cost was put forward by Mr. Aubrey Jones, the Minister of Fuel and Power, as a reason for the lack of greater progress in developing district heating in this country. Mr. Austen Albu (Labour), who raised the matter, suggested that the Minister should set up a committee to inquire into the economic possibilities of combining electricity generation and district heating, by the use of small power stations sited in the vicinity of large new housing estates or new towns. This the Minister declined to do, on the ground that progress in that field was limited not by the lack of knowledge, but by the high cost to the consumer, and he emphasised that that high cost applied even in areas where there was a concentrated demand for heat as well as electricity.

Mr. Albu pointed out that the economics of having separate schemes for electricity generation and district heating were very different from those of combined schemes using back-pressure steam, and suggested that Britain was much behind other countries in trying out schemes of this kind, which were very economical in regard to fuel. Mr. Jones replied that the economics of the subject were complicated. Rightly or wrongly, Britain had gone in for large power stations, resulting in low operating costs. That meant, however, that in any attempts to distribute the heat, the consequent costs of distribution were all the higher. Moreover, Mr. Jones told the House, these costs were more than could be offset by the reduced operating costs at these large power stations.

AIRCRAFT DEVELOPMENT COSTS

Particulars were given by Mr. Reginald Maudling, the Minister of Supply, regarding the development and other costs incurred by his Department on account of some recent British civilian aircraft. The Minister informed Mr. George Brown (Labour) that the total expense borne by the Department in respect of the development of the Viscount and the Ambassador were £1,800,000 and £1,500,000, respectively. Expenditure to date on the development of the Britannia series of aircraft amounted to £5,800,000. This expenditure was recovered wholly or partly by levies imposed on the sales of production aircraft and spare parts.

Prestressed Concrete for Roads

Experiments on the behaviour of prestressed concrete when used for road construction are still being conducted, according to an answer given by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation. He told Vice-Admiral John Hughes-Hallett (Conservative) that, until more experience was available, he would not authorise the use of prestressed concrete on motorways. Mr. Watkinson had recently estimated that 300 tons of steel would be required for each mile of these motor roads, and he now informed Admiral Hughes-Hallett that, if prestressed concrete were used in their construction, it might mean a saving of 50 per cent. in the amount of steel required. The cost of the work would be increased, however, owing to the specialised nature of the prestressed concrete process.

Electrical Machinery Monopoly Report

The report of the Monopolies and Restrictive Practices Commission on the supply and exports of electrical and allied machinery and plant was sent to Mr. Peter Thorneycroft, the President of the Board of Trade, on July 17. According to a reply by Mr. Thorneycroft to Mr. Anthony Kershaw (Conservative), this report will be laid before Parliament in due course, in accordance with section 9 of the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948.

Negative Answer

British subjects holding degrees or diplomas in technical, engineering or scientific subjects who have left this country to take up positions overseas were the subject of a question by Mr. J. M. Baldock (Conservative). He asked the Minister of Labour and National Service how many such persons had left Britain in each of the last three years for which statistics were available and how many immigrants possessing similar qualifications had entered this country. In reply, Mr. Robert Carr, the Ministry's Parliamentary Secretary, said that this information was not provided for in the available statistics of emigration and immigration.

Radio-Chemical Research

In his capacity of representative in the House of Commons of the Lord President of the Council, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Works, was asked about the work of the Chemical Research Laboratory. Mr. Arthur Skeffington (Labour) wanted to know why, having regard to the responsibilities of the United Kingdom Atomic Energy Authority, the energies of nearly one-quarter of the staff of the Chemical Research Laboratory of the Department of Scientific and Industrial Research were occupied on radio-chemical work. Mr. Bevins said that this work was carried out under contract for the Authority, and at its expense, because it was mutually agreed between the two organisations that that procedure was the most convenient and economical arrangement. The staff of the Chemical Research Laboratory had been specifically augmented from time to time for this purpose.

Cabs for Farm Tractors

Sir Alfred Bossom, Bt. (Conservative) drew the attention of the Minister of Agriculture, Fisheries and Food to the need for further consideration to be given to the design of agricultural tractors, in order that it might be easier and cheaper for satisfactory cabs to be fitted. In reply, Mr. Heathcoat Amory said that cabs of generally satisfactory design were now available for all the more popular makes of tractor and could be readily fitted. All the same, he would convey the suggestion to the joint consultative committee of the Agricultural Engineers' Association and the National Farmers' Union, which would be able to consider any points of design which might need further attention.

Standardisation of Agricultural Machinery

Another suggestion put forward by Sir Alfred Bossom was that the Minister of Agriculture should summon a conference of manufacturers, farmers' organisations and other interested persons to co-operate in obtaining a better standardisation of agricultural machinery parts, as this would prove of general benefit to farmers. On this point, Mr. Amory said that the agricultural machinery and implements industry standards committee of the British Standards Institution, which included representatives of the persons and organisations mentioned by Sir Alfred, had been formed for that purpose. In his opinion, Mr. Amory said, the formation of that committee provided for the full consideration of all aspects of the problem.

Carbonisation Plants' Surplus Gas

Mr. Harold Neal (Labour) drew the attention of Mr. Aubrey Jones to the decision of the East Midlands Gas Board, in mid-July, to increase the price of gas, and stated that, on the very day that this increase was made known, the carbonisation officer of the National Coal Board announced that £120,000 worth of gas from carbonisation plants was being turned to waste because that Gas Board would not accept it. The Minister of Fuel said that what had happened in the East Midlands area was one of the teething troubles which so often arose when a new plant was started. Even so, the amount of gas lost in that area in May and June was 4½ per cent. of the total gas supplied by the N.C.B. in the area, and less than 1 per cent. of the Board's average sale in the summer. There was close and continuous co-operation between area Gas Boards and the N.C.B. on the use of gas from carbonisation plants.

Courses at Technical Colleges

Sir David Eccles, the Minister of Education, stated that, under the new regulations, neither colleges of advanced technology nor regional colleges which prepared students for university degrees would be prevented by him from continuing to do so, provided that the courses concerned remained efficient and economical. At the same time, for reasons given in the recent White Paper on *Technical Education* (Cmd. 9703), it was important that students in technical colleges should be able to work for a qualification of high standing that would not involve the disadvantages inherent in an external degree. He told Mr. J. E. MacColl (Labour) that there would be no difference between regional and national colleges in regard to the Hives' award, and the Government considered that it would be more in the interests of the students themselves that courses should be drawn up to suit local requirements and, possibly, local industries. It was in that direction that the disadvantage of the external degree lay.

In his inquiry, Mr. MacColl had suggested that, if the regional colleges were encouraged to provide university courses, it would increase the quality of their staffs and make these colleges feel that they were not being discriminated against in favour of the national colleges.

THE HUMAN ELEMENT

Improving professional men's pay—Annual conference of the Labour Party—The root of labour trouble in the docks—Rank and file support for strikes—Administration of labour in the colonies —Money talks in the U.S.S.R. too.

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The Doctors' Pay Claim

The reaction of doctors to the rejection of their claim " for an adjustment in the remuneration of general practitioners and all grades of medical hospital staff " has generated a spirited reply from the British Medical Association. In a letter to *The Times*, Mr. Angus Macrae, secretary of the negotiating committee challenges the accuracy of a statement by the Ministry of Health that " looking at the picture as a whole, general practitioners have, under the Danckwerts award, reached a point 137 per cent. above their pre-war earnings." Mr. Macrae argues that, in the first place, too many practitioners before the war were earning incomes lower than recommended by the Spens Committee and approved by the Ministry and secondly there are now 20,600 general practitioners compared with 18,000 before the war. The increase in the total income is 137 per cent. higher—£66·0 million in 1953/54 compared with £28·1 million pre-war —but the average income (including professional expenses which have increased more than proportionately) is only about 100 per cent. The B.M.C. contend that this is completely inadequate —and that the medical profession will continue to press for an adjustment related to the fall in the value of money and the increases in remuneration in other occupations since April 1, 1951.

The claims of professional men, whether they be doctors or teachers, often fail to arouse much sympathy even in Government circles. The increase the doctors are seeking—24 per cent. above the 1953/54 remuneration rates—would in the Ministry's estimate, cost the taxpayer an additional £20 million a year or about £1,000 per general practitioner. This is very unlikely to be granted by a Government so completely committed to a policy of " price freeze." Yet if the British professions are squeezed much more they will find it difficult to maintain the high standards that are the pride of the nation.

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Blackpool Illuminations

When the Labour Party meets for its annual conference this year at Blackpool, it will face an agenda which has been pruned from 402 constituency resolutions. Not all these wild horses will run the classic Blackpool course in October, but it is already apparent that such issues as automation and redundancy will be forced to the front.

Viewed in the large, the 400-odd starters are not a bad lot. There is the usual batch of wild proposals such as a demand for the socialisation of housing—whatever that may mean. There is the customary crop of rude suggestions about the *Daily Herald* and socialists who become peers. These last are indeed no more than a public family bicker. But the resolutions on automation and on redundancy show a good deal of thought and with certain exceptions an absence of wild, doctrinaire recommendations. There are those within the Labour Party who see the need to welcome automation as a means of keeping export costs down. There are others who see that automation must mean dislocation of the labour market and who therefore concentrate on means of mitigating those effects.

One thing is certain this year: the Labour Party has a strong tactical advantage at the moment. Nothing would suit it better than to fall heir to a successful deflationary policy after the next general election. Between now and October, the present Government's deflation tactics will be under severe strain. The next few months could be crucial. Nothing is surer than that the trend of current events will, in consequence, play a big part in the atmosphere of the Labour Party when it meets in conference two months from now.

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Dock Labour Inquiry

A new spirit rather than a new employment machinery is advocated as a solution to the perennial troubles of the docks. The committee of inquiry were set up last year under the chairmanship of Mr. Justice Devlin. Rejected is the port employers' proposal that they should assume complete control of the dockers and that the principle of joint control by both sides of the industry should be done away with. In fact the committee consider that the machinery of dual control should work and could be made to work with good will on both sides. Other suggestions for changes in the machinery of the scheme are also rejected, including the employers' proposals for a tightening up of disciplinary measures: " If the scheme is made use of as a strike-breaking weapon it will itself break. The time will come when the unofficial strike is more fully recognised as discreditable. Until it does, the disciplinary provisions of the scheme, which are primarily designed to cover cases of individual indiscipline, must be used against strikers with as much restraint as in similar cases in other industries employers use the powers of dismissal."

The committee have concluded that the decision to base the scheme on the idea of partnership was sound in principle and should be persevered with. On the whole the Devlin report is a rounded condemnation of the attitude of the port employers to their labour problems. The suggestions that the two sides of industry will get on better with the management of the labour force if they think of themselves as partners rather than bargainers is perhaps a statement of the obvious, but it is surely well worth trying. It is perhaps not entirely impossible that the industry will settle down to a smoother and easier relationship.

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The B.M.C. Strike

The effects of the B.M.C. strike have continued to spread. Briggs Motor Bodies were unable to maintain production owing to their inability to get supplies from Fisher and Ludlow (one of the B.M.C. companies) and the serving of " protective " notices on 2,000 men (now withdrawn by the management) led to a lightning strike of all the company's 12,000 workers. If the B.M.C. strike continues after the holidays Standard may have to dismiss a further 1,000 employees. Several component manufacturers have announced impending sackings owing to sharply reduced order schedules, or have advanced their holiday to coincide with that of B.M.C. Support for the strike was given by the N.U.R. and A.S.L.E.F., who refused to handle B.M.C. products.

The most surprising feature of this strike is perhaps the unions' failure to enlist much more than 50 per cent. support from the rank and file. Previously, when strikes have been for higher pay, over demarcation or internal disputes, the rank and file have almost invariably moved ahead of the union leaders and got almost complete support. The strike at Rolls-Royce's Glasgow factory group was a case in point. The B.M.C. strike has shown beyond any doubt that redundancy is not an issue which ranks in the workers' minds with pay claims, or the maintenance of restrictive practices. This perhaps is why the unions have done so little about it and been caught very much unawares.

Compensation is one of the two basic issues. Little is likely to be settled during the men's holiday and this may mean that overhaul and maintenance work will not be done. The general impression is that the Unions are deeply disturbed at the turn of events, and that the shop stewards have completely misled union leaders as to the temper of the men.

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Arbitration in the Colonies

In industrially advanced countries, the function of the impartial conciliator or arbitrator is of great importance. It is exercised by union federations like the T.U.C. in this country and also by some key Government department—in this country by the Ministry of Labour. The development of this side of industrial relations machinery is in fact a sign of industrial maturity.

In the colonies, trade union organisation is growing apace and it has much to learn. It is inevitable that as it progresses the labour departments of the Governments concerned will become increasingly concerned with such functions which fall to the Ministry of Labour here. Their paternalistic attitude—in some cases it has amounted to a vague patronising paternalism —will not be tolerated as unions grow in power. In these circumstances it is all to the good that a labour administration conference should have met last month in Oxford to discuss labour problems in the colonies with representatives present from 27 colonial labour administrations as well as from the Colonial Office. In the second week of the conference, officials taking part were joined by Ministers responsible for labour matters. Among subjects discussed were wages policy, wage regulating machinery, industrial relations including conciliation techniques and arbitration, legislation affecting disputes in essential industries and certain matters arising in federated territories. The attendance of Ministers in the second week was something of a novelty and it is hoped that it may be repeated at another conference in a year or two's time. There is certainly much to be gained from a cross-fertilisation of ideas on labour relations between colonies at this very critical formative period.

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Russian Fruit Salad

From time to time the Russians employ the tools of capitalism to achieve the ends of socialism. The end, one presumes, justifies the means. At times these means are used with almost Draconian ferocity. For example, periodic revaluations of the rouble to combat inflation (an obscene economic disease only officially cognised in Russian writing in terms of decadent capitalism) have occurred with a ruthlessness which makes the memory of Montagu Norman redolent with financial philanthropy.

The latest excursion into capitalism concerns fruit. There is official dissatisfaction with the amount of fresh fruit coming on to the market in Russia. In consequence, the central committee of the Communist Party and the U.S.S.R. Council of Ministers have decided that inducements shall be offered the workers on collective farms to grow soft fruit on their own patches which may be sold at free market prices. To judge from the present free price which exists after a fashion alongside the official prices ruling in the State shops the private growers will get a useful premium. Until recently, urban dwellers were encouraged to improve their milk and meat supplies by buying a few cows and other livestock. A straightforward money incentive has thus gained official currency again even if it cannot yet aspire to complete respectability.

It is always possible, of course, in Russia that what is tolerated to-day may become heresy to-morrow, depending on how the economic and idealistic winds blow. For the moment, however, a price incentive has come to the orchards of Russia. The aim is raspberries for the Russian consumer. Perhaps raspberries too for the unbending ideologists?